Section 6
Technical Data

page contents

Specifications

It is impossible to define the listening quality of even the simplest limiter or compressor with the usual specifications because they cannot adequately describe the crucial *dynamic* processes which occur with program material. We evaluate these dynamic processes at the factory and control them to close tolerances. These measurements require special test fixtures, cannot be readily duplicated by measurements with standard test equipment in the field, and cannot be described in familiar terms.

OPTIMOD-AM is the result of computer-aided design, high-precision components, careful testing, and extensive burn-in. When OPTIMOD-AM's MODE switch is set to PROOF, clipping and gain reduction are defeated *without bypassing any circuitry* — unlike equipment produced by some other manufacturers. (A separate switch defeats transmitter equalization.) Because of this, the following specifications truly reflect the accuracy and transparency of OPTIMOD-AM's signal path.

Performance

Frequency response: ±1.0dB, 50–9500Hz (optional 5kHz filters defeated and MODE switch set to PROOF).

Total harmonic distortion: <0.2% at 100% modulation, 50–9500Hz (MODE switch set to PROOF).

RMS noise: >65dB below 100% modulation, 30–20,000Hz (MODE switch set to PROOF).

Separation (9100B/2): >25dB, 50–5000Hz; >20dB, 5000-7500Hz; 30dB typical, 50-5000Hz (MODE switch set to PROOF).

Stereo 9100B/2 units contain a subsystem designed to protect C-Quam receivers by limiting left or right channel negative peak modulation to −75% (where 100% = full negative envelope modulation) through asymmetrical clipping in left and right channels. Dynamic gain reduction in the L–R channel prior to this clipping prevents clipper overdrive by momentarily reducing separation when it is high. Such gain reduction is constrained to 6dB or less, as required by the program material. Mono receivers are unaffected and retain full loudness. The STEREO ENHANCE trimmer on Card #1S10 can increase L–R gain by up to 6dB.

Dynamic separation is typically 30dB (with pink noise signal and MODE switch set to OPERATE).

Installation

Audio Input

Configuration: Left and right.

Impedance: >10K ohms, electronically balanced.

Sensitivity: −30dBu to +8dBu nominal line levels.

Controlled by INPUT ATTEN controls. 20dB input attenuation pads can be defeated by repositioning jumpers.

0dBu=0.775V rms.

RFI suppressed: Yes.

Connector: Barrier strip (#6 screws).

Audio Output

Configuration (mono 9100B/1): Outputs for two transmitters, each with separate equalization and output level set-up controls.

Configuration (stereo 9100B/2): L+R/L−R or L/R. Outputs for two transmitters, each with separate equalization and output level set-up controls and stereo generator.

Impedance: 290 ohms, electronically-balanced to ground.

Level: >+20dBm into 600 ohms.

RFI suppressed: Yes (by third-order non-overshooting EMI filter).

Connector: Barrier strip (#6 screws).

Power

Power requirement: 115/230V AC (±15%), 50/60Hz, 30VA.

Connector: IEC mains connector with detachable 3-wire 'U-ground' power cord and plug supplied.

Protection: AC power input is RFI-suppressed. UL/CSA/BSI/VDE line filter.

Fuse: ½-amp Slow-blow for 115V operation; ¼-amp fuse of the same type for 230V operation. An adaptor for 5mm x 20mm Type T fuse can be supplied for Europe.

Physical

Dimensions: 19 inches (48.3 cm) wide, 7 inches (17.8 cm) high, 12.5 inches (31.2 cm) deep. Requires 4 EIA rack units.

Operating temperature range: 0–50°C (32–122°F).

Humidity: 0–95% RH, non-condensing.

Circuitry

Input Conditioning

High-pass filter: −0.5dB at 50Hz, with >18dB/octave roll-off below 50Hz. Includes deep 25Hz notch for automation cue tones, and to protect the C-QUAM pilot tone.

Low-pass filter: Rolls off frequencies above 12kHz at >24dB/octave.

Phase scrambler: All-pass network makes peaks more symmetrical to best utilize the capabilities of the processing.

Broad-band Compression

Range of compression: 25dB.

Compression ratio: >10:1.

Attack time: Approximately 200ms (when TIME CONSTANT switch set to SINGLE) *or* program-controlled (when TIME CONSTANT switch set to MULTI).

Release rate: Approximately 3dB/second (when TIME CONSTANT switch set to SINGLE) *or* program-controlled (when TIME CONSTANT switch set to MULTI).

Total harmonic distortion: Does not exceed 0.05% at any amount of gain reduction, 50–9500Hz.

Noise: >85dB below output clipping level.

Gating: Gain reduction will slowly change to 10dB if input level drops below a user-adjusted threshold.

Program Equalization

Bass: 'Quasi-parametric' second-order peak boost equalizer. Q (bandwidth) range is 0.3–1.4. Center frequency (tuning) range is 70–110Hz. Boost (equalization) range is 0–+6dB.

High-frequency: Four plug-in 'personality modules' supplied.

The BLUE module provides standard NRSC 'modified 75μs' pre-emphasis. The RED, YELLOW, and GREEN modules each provide a family of third-order shelving curves with adjustable (by HF EQ controls) ultimate high-frequency boost.

Six-band Limiting

Filters: 150Hz low-pass; 420Hz, 700Hz, 1.6kHz, and 3.7kHz bandpass; 6.2kHz high-pass. 18dB/octave selectivity, parallel topology.

Outputs of all filters combine to yield a static frequency response of ±0.5dB, 50–9500Hz. Phase interaction between filters under program conditions will not cause audible dips in the frequency response.

Range of gain reduction: 25dB (lower five limiter bands), 30dB (6.2kHz band).

Attack time: Program controlled; adjusted according to band frequency.

Release time: Program controlled; adjusted according to band frequency.

Total harmonic distortion (each limiter): ≤0.1% for any frequency in the limiter's passband with any amount of gain reduction, provided signal is below the multi-band clipper threshold.

Distortion cancelation: All clipper-induced distortion in upper four bands is canceled by >30dB below 2kHz. Additional distortion reduction is provided as a function of frequency in each band.

Noise (each limiter): >85dB below VCA output clipping level.

Output Filtering

Filter characteristics: 12kHz, 10kHz (NRSC standard), and 5kHz (30dB/octave) low-pass filters standard (single-channel 4kHz, 4.5kHz, 5kHz, 5.5kHz, and 6kHz low-pass filters available upon special order). Low-pass filters can be configured (with jumpers) to follow DAY/NIGHT switching in any combination.

With respect to the power spectrum at OPTIMOD-AM's output: The 12kHz filter is guaranteed to meet FCC 73.40.a.12 occupied bandwidth requirements. The 10kHz filter is guaranteed to meet the NRSC-1 power spectrum specification. The optional 4, 4.5, 5, 5.5, and 6kHz filters are guaranteed to meet CCIR 328-5 as specified for their nominal bandwidths. All filters are phase-corrected and overshoot-free when observed at OPTIMOD-AM's output.

Stereo high-pass filters: Stereo 9100B/2 units have defeatable 200Hz L–R 30dB/octave high-pass and phase-matched L+R all-pass filters to protect L–R SCA or telemetry.

Transmitter Equalization

Low-frequency tilt equalizer: Proprietary phase/magnitude compensation introduces adjustable positive-slope tilt to the output waveform to cancel normal negative-slope tilt in older transmitters. Independent control of very-low-frequency compensation avoids saturation and non-linear effects in transmitters with limited low-frequency power handling capacity.

High-frequency shelving equalizer: Adjustable breakpoint shelving equalizer creates controlled undershoots in high-frequency transient waveforms to prevent RF envelope overshoot due to excessive Q in transmitters, phasers, or antenna systems — or due to poor transient response in audio or modulator stages.

High-frequency delay equalizer: Selectively introduces added time delay into the spectrum to compensate for non-linear group delay in the transmitter/antenna system, thus optimizing transient response by creating approximately constant time delay at all frequencies within the audio bandwidth.

Controls: Four separate sets of controls (DAY/TX1, NIGHT/TX1, DAY/TX2, and NIGHT/TX2) enable switching between four different transmitter equalization set-ups. Switching can be effected by front panel switches or by remote control.

Warranty

One year, parts and labor: Subject to limitations set forth in our Standard Warranty. Factory assistance and service will be available throughout the life of the product.

All specifications subject to change without notice.

Circuit Description

Where the circuitry is duplicated for the left and right channels, only left (or L+R) channel reference designators will be identified.

1. Overview

The block diagram on page 6-61 illustrates the following overview of OPTIMOD-AM circuitry.

The input signal is applied to an **RFI suppression network** and an **attenuation pad** (which can be strapped for 0 or 20dB attenuation). Then, the audio is applied to a low-noise true instrumentation **input amplifier** (gain is set with the INPUT ATTEN control). The level of the signal out of the amplifier determines the amount of gain reduction applied by the broad-band automatic gain control circuitry.

The signal is then applied to a **12kHz low-pass filter** to prevent out-of-band high-frequency energy from being processed, and to minimize any potential intermodulation between in-band and out-of-band components. To make more efficient use of OPTIMOD-AM processing (and help achieve maximum loudness), asymmetrical signal waveforms are made more symmetrical with a **phase scrambler**. A **50Hz high-pass filter** with a deep notch at 25Hz eliminates modulation-wasting subsonic energy from turntable rumble and other sources, eliminates distortion caused by modulation of the compressor control voltages by such subsonic energy, and filters out automation cue tones.

The input-conditioned audio drives the **broad-band automatic gain control (AGC)** circuit. The broad-band AGC helps achieve consistent sound (despite normal production variations and operator sloppiness) by compressing the dynamic range of program material. Because the broad-band AGC is not designed to produce significant augmentation of program density (the six-band limiter does that), its attack and release times are either slow at all times, or slow except when large changes of level have occurred. Setting the TIME CONSTANT control to SINGLE selects the former (best for music and program with well-controlled levels), while the MULTI setting selects the latter (useful in talk and location material characterized by wide variations in input level).

Gating prevents audible noise pump-up. When the signal level into the broad-band AGC falls below the level set by the GATE THRESH control, the gain of the circuit is held approximately constant. If the input level is below the gate threshold for more than a very brief time, the gain of the broad-band AGC will slowly move toward 10dB gain reduction (= 0 on the BROADBAND AGC G/R meter). The gating threshold level detector is limited to the 100–3000Hz band to prevent false ungating on noise.

The broad-band AGC's output drives the bass and high-frequency program equalizers.

The 'quasi-parametric' **bass equalizer** provides control of the peak equalization frequency (with the BASS TUN control), the amount of equalization (with the BASS EQ control), and the equalization bandwidth (with the BASS BW control). Although adjusting the frequency or boost will change the fractional bandwidth, the controls are otherwise non-interacting. The output of the bass equalizer's dual-amplifier quasi-parametric bandpass resonator is summed with the unequalized signal in the high-frequency equalization amplifier.

OPTIMOD-AM's high-frequency equalization curve is defined by the color-coded pre-emphasis module on Card #4 (and #5 in a stereo 9100B/2). OPTIMOD-AM is shipped with the **BLUE pre-emphasis module** installed. This module provides the NRSC recommended pre-emphasis curve when OPTIMOD-AM's HF EQ control is turned fully clockwise. We strongly recommend that broadcasters in the Americas use the BLUE module (see page 1-16). Broadcasters using the 4.5kHz filter in Card #1F4.5 may wish to use the GREEN module, which provides pre-emphasis better suited for the very narrow-band radios often found in those countries.

With the BLUE module, the HF EQ should be set to 22dB (which in fact provides the 10dB maximum boost defined in the NRSC-1 standard) — no further adjustment is necessary.

Because some broadcasters may have different requirements or preferences, OPTIMOD-AM package includes three modules besides the BLUE module:

The **RED module** is reasonably compatible with both the new wideband radios and the older narrowband radios. Its sound is generally brighter than the BLUE module. It sounds very acceptable through an NRSC radio, although its added brightness may tend to increase the first-adjacent interference being generated by your station, contrary to the purpose and intentions of the NRSC.

The **GREEN module** provides the same equalization originally supplied as standard on early OPTIMOD-AM units. Compared to the other modules, it provides much more boost in the 5kHz region, and tends to sound strident on the new NRSC and other wideband radios. The radios that can gain significant benefit from this module are vanishing in North America. Its pre-emphasis can only be appreciated on narrowband radios with relatively gentle IF slopes. Newer narrowband radios are being manufactured with steep-slope IF filters designed for best selectivity, and many of these radios will sound significantly distorted when this pre-emphasis is used unless bandwidth is limited to 4.5kHz at the transmitter by Card #1F4.5. We can, therefore, no longer recommend it for use in NRSC countries, but it can be very effective in 4.5kHz countries where narrowband radios remain the norm.

With the GREEN module installed, an HF EQ control setting of 22dB will result in a perceived bandwidth of 6kHz on 'type 2' AM radio (see page 3-8); a 15dB setting yields a 5kHz perceived bandwidth, 10dB yields 4kHz, and 5dB yields 3kHz.

The **YELLOW module** offers a compromise between the GREEN and RED modules.

The YELLOW and RED modules produce progressively less boost in the 5kHz area. This substantially reduces presence and loudness on conventional narrowband radios, but is quite helpful in reducing the edgy, strident quality that the GREEN module's equalization curve can induce in wideband radios with sharp roll-offs (like the 1984-1985 Delco AM stereo set).

Curve families for all the pre-emphasis modules are shown in Fig. 3-2 on page 3-15.

The equalization curves defined by the RED, GREEN, and YELLOW modules are based on a statistical study of common American, European, and Japanese home and automobile radios.

From the program equalizers, the stereo 9100B/2 left and right channel signals are transformed by the **sum-and-difference matrix** into sum-and-difference (L+R and L−R) signals. (In mono 9100B/1 units, the matrix is bypassed.)

The **six-band limiter** divides the signal into six frequency bands. Since the average AM receiver is only flat to about 1.5–2kHz, the midrange is far more important in AM than in FM. OPTIMOD-AM's six-band limiter is designed to give you precise and versatile control over midrange audio. This expanded control makes possible a more consistent, intelligible, and pleasing sound — even with widely varying program material. The six bands are particularly useful for correcting intelligibility problems with low-grade speech from telephone calls or other actualities.

The six-band limiter is also an unusually effective high-frequency limiter; the program controlled release time circuitry permits as much as 25dB compression of a high-frequency band without audible side effects.

To permit large amounts of limiting without interaction and pumping, the six-band limiter filters have been designed with 12dB/octave slopes. When the filters' outputs are summed after the following multi-band clipper (which contains further filtering), the resulting output is typically flat (±0.25dB) over the frequency range of the 9100B. These filters have been carefully designed to prevent audible 'holes' in the frequency response from occurring in dynamic conditions.

Each filter is followed by its own limiter. Because the characteristics of these limiters are *extremely* critical to proper frequency response and inaudible operation, they are not user-adjustable. The DENSITY control sets the level of the signal going into the six-band limiter. The CLIPPING control adjusts the threshold of limiting of all six band-limiters simultaneously, which controls their output level and (therefore) the input level for the following multi-band clipper. Together, the DENSITY and CLIPPING controls determine the amount of multi-band limiting: turning the DENSITY control clockwise and/or turning the CLIPPING control counterclockwise will produce more limiting.

> Because it operates in several frequency bands and exploits the 'masking' effect, the six-band limiter is capable of far more *fast* gain control without audible side-effects than is the broad-band AGC. The six-band limiter can substantially improve the peak-to-average ratio of the signal *without* the modulation effects which would result if only one limiter were used for the entire frequency spectrum.
>
> OPTIMOD-AM is fundamentally different from other multi-band audio processing systems because its multi-band section is primarily a *limiter*, not a *compressor*. Devices which attempt to compress audio with a multi-band AGC run a severe risk of causing unnatural frequency balances if their input levels are not well-controlled. This is because certain bands may exhibit heavy gain reduction while others may exhibit little or none. Heavily reducing the gain of some bands while others are not attenuated at all tends to overemphasize the unattenuated bands. To avoid such problems, average levels into OPTIMOD-AM's six-band limiter are controlled by the slow broad-band AGC.

The output of each of the six band-limiters is applied to a separate **distortion-canceling clipper**, followed by filters to reduce the out-of-band harmonic and intermodulation distortion caused by the clipping. In addition, the distortion caused by clipping the upper four bands is cleaned up by a 12kHz low-pass filter, and is sharply canceled below 2kHz by a parallel feedforward distortion-canceling sidechain.

The distortion filtering and cancelation effectively reduces the peak-to-average ratio of the signal without distortion build-up due to clipping. The result is an extraordinarily favorable trade-off between loudness and distortion. Because the summed outputs of the six clippers can be applied to a safety clipper for final peak limiting without the need for further broad-band gain control, potential pumping and modulation effects are avoided.

In stereo 9100B/2 units only, the output of the six-band limiter and distortion-canceling multi-band clipper is applied to an optional, jumper-selected **200Hz L–R high-pass filter**, which protects the low-frequency part of the L–R channel so it can be used for telemetry or low-frequency SCA. Also only available in the stereo 9100B/2 are: an optional **single-channel limiter** (which limits negative peak modulation to 75%, as required by some exciters), and an optional **stereo enhancer** (which increases the level of the L–R signal up to 6dB above that of the L+R signal).

In both stereo and mono OPTIMOD-AM units, the signal is then **low-pass filtered** to minimize interference with other AM stations. One of three cut-off frequencies can be selected: the 10kHz low-pass filtering recommended by the National Radio Systems Committee (NRSC), 12kHz, or 5kHz. (4kHz, 4.5kHz, 5kHz, 5.5kHz, and 6kHz low-pass filters meeting CCIR 328-5 are available upon special order. These can only be fitted to mono units.) The low-pass filters can be preset with jumpers, and switched by OPTIMOD-AM's day/night logic.

The low-pass filter is followed by a **safety clipper** to eliminate overshoots induced by the low-pass filter or by the addition of the feedforward distortion-correction signal in the multi-band distortion-canceling clipper.

After the safety clipper, a **supersonic non-overshooting low-pass filter** controls any potential adjacent-channel interference that might be caused by the safety clipper.

The supersonic low-pass filter drives a three-stage **transmitter equalizer,** which pre-distorts the shape of the final-clipped waveform to compensate for non-flat response in the transmitter.

The first stage of the transmitter equalizer is an adjustable all-pass network which can add delay to improve the pulse response of transmitter/antenna systems with non-constant group delay. The second stage provides a shelving roll-off which will reduce or eliminate high-frequency roll-off in the vast majority of antenna/transmitter systems that have high-frequency roll-off problems. The third stage provides low-frequency tilt equalization in the L+R path (only) by creating a *positive slope* tilt in the output waveform to cancel the negative-slope tilt introduced by many plate-modulated transmitters.

Four sets of controls define four different transmitter equalization set-ups. Only one set of controls is active at any given time. Which set is active is determined by the momentary DAY/NIGHT and TX1/TX2 switches, or by remote control signals through optically isolated rear-panel terminals.

In stereo 9100B/2 units only, a **de-matrix** circuit transforms the L+R and L−R signals back into L/R format (in mono 9100B/1 units, the de-matrix is bypassed). Ordinarily, the output of the de-matrix feeds the output line amplifiers. By repositioning jumpers, the line amplifier can be fed by L+R and L−R signals.

The **output line amplifiers** are driven through the OUTPUT ATTEN controls. The output of these balanced amplifiers passes through an EMI filter before being presented at the output terminals on OPTIMOD-AM's rear panel.

2. Input amplifier

Located on Cards #4 and #5

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

Because the input is DC-coupled, only small amounts of differential DC should be applied to the input. Since the input would typically be fed by the output of a transformer or capacitively-coupled amplifier, this should not be a problem. Slight amounts of DC offset are eliminated in the 50Hz high-pass filter that follows the input amplifier.

Component-level description:

The input is RF-filtered, then applied to 10K bridging pad R1, R4. Strapping R2 and R3 into the pad introduces 20dB attenuation (OPTIMOD-AM is shipped with R2 and R3 strapped in).

The output of the pad is connected to low-noise true instrumentation amplifier IC13a, IC14a, IC14b, and associated resistors. R5, R6 provide bias current for IC14, which is a low-noise bipolar-input dual IC opamp. R9, R10 are feedback resistors for the two sections of IC14. The differential gain is controlled by the series resistance of R8 and INPUT ATTENuator control R7. The common-mode gain of the IC14 pair is 1.

The differential output of IC14a and IC14b is converted to a single-ended output; the common mode component of the output is nulled by differential amplifier IC13a and associated resistors.

Nearby lightning strikes may induce energy into OPTIMOD-AM's audio input that is sufficient to pass through the RFI protective networks and destroy IC14. If OPTIMOD-AM is installed in a lightning-prone location, keep spare NE5532 chips in stock. Installation of varistors between each side of the audio input lead and earth may help prevent such problems.

3. 12kHz Low-pass Input Filter

Located on Cards #4 and #5

The output of the input amplifier is applied to a fourth-order 12kHz low-pass filter, which prevents out-of-band high-frequency energy from being processed, and minimizes any potential inter-modulation between in-band and out-of-band components. This is particularly important if large amounts of high-frequency boost are employed in the following equalization circuitry.

To ensure maximally flat response from the entire OPTIMOD-AM system, the frequency response of the 12kHz low-pass input filter has been designed to equalize frequency response losses in the 12kHz low-pass output filter and supersonic low-pass filter.

Component-level description:

The 12kHz low-pass input filter consists of two cascaded, unity-gain, positive feedback active filters. The first (low-Q) section consists of R15, R16, C1, C2, IC13b. The second (high-Q) section consists of R17, R18, C3, C4, IC12a.

This type of active filter is described in many modern texts on active filter design (see, for example, chapter 6 of Wong and Ott: *Function Circuits.* McGraw-Hill, New York).

4. Phase Scrambler

Located on Cards #4 and #5

Although the overload points of the AM carrier are asymmetrical, USA regulations permit only 125% positive modulation, and therefore only 1.94dB asymmetry. Because many voice and musical waveforms are far more asymmetrical than this, maximum loudness can best be achieved by phase-shifting asymmetrical input waveforms to make them symmetrical before any processing occurs.

OPTIMOD-AM accomplishes this with a combination of a first-order all-pass filter (phase-shifter) in series with a second-order all-pass filter in the six-band crossover (see page 6-20). The crossover introduces further phase shift and completes the phase scrambling system.

The phase scrambler is a low-Q circuit that does not introduce ringing. Its audible effect is extremely subtle. It can be heard as a very slight change in the sound of some voices. Music, in general, is audibly unaffected. Despite the fact that square waves emerging from the scrambler no longer look like square waves, the purist should not fear that it is degrading audio quality. It is in fact significantly improving subjective distortion performance of the system.

Component-level description:

The all-pass phase scrambler consists of two unity-gain phase-shift sections in series. Each has a flat frequency response, but a phase response that varies as a function of frequency.

The first section's phase response varies from 0° to 180° as a function of frequency. It consists of IC12b, R19, R20, R21, C5.

The second section's frequency response varies from 0° to 360° as a function of frequency. It consists of IC11a, R22, R23, R24, R25, R26, C6, C7. Close matching of R22 and R23 is particularly important to ensure flat frequency response.

5. 50Hz High-pass Filter

Located on Cards #4 and #5

The output of the phase scrambler is applied to a third-order elliptical high-pass filter with a 50Hz cut-off frequency (0.5dB down), a 0.5dB ripple, and a deep notch at 25Hz (to eliminate automation cue tones that other filtering may have missed). This filter was not designed to be conveniently bypassed because it eliminates modulation-wasting subsonic energy from turntable rumble and other sources, eliminates distortion caused by modulation of the compressor control voltages by such subsonic energy, prevents introduction of distortion in transmitters (which could be exaggerated by the transmitter equalizer), and prevents loss of loudness in most receivers (which cannot reproduce audio below 50Hz).

Component-level description:

The first-order section of the 50Hz high-pass filter is realized by C10 and the input resistance of the following broad-band automatic gain control VCA on Card #2 or #3.

The second-order section realizes the 25Hz notch, and consists of IC11b, R27, R28, R29, R30, R31, R32, R33, C8, C9. To achieve flat response to 50Hz from the entire filter, the frequency response of this section is peaked slightly above 50Hz to equalize the gentle roll-off provided by the first section.

6. Broad-band Automatic Gain Control (AGC)

Located on Cards #2, #3, and #6

Broad-band automatic gain control is provided by a feedback compressor, made up of voltage-controlled amplifiers (on Cards #2 and #3) and associated control circuitry (on Card #6).

OPTIMOD-AM uses proprietary class-A voltage-controlled amplifiers (VCAs), operated as two-quadrant analog dividers with gain inversely proportional to a current injected into the gain-control port. A specially-graded Orban IC contains two matched non-linear gain-control blocks with differential inputs and current outputs. The first of these is employed in the feedback loop of an opamp to perform the gain control function. The inputs of the first and second gain-control blocks are connected in parallel. The output of the second block is a distortion-corrected *current* which is transformed into the desired gain-controlled voltage by an opamp current-to-voltage converter. The VCAs produce less than 0.05% harmonic or intermodulation distortion; overload-to-noise ratio is approximately 90dB.

VCA output is applied to a control circuit. If the average output level of the VCA attempts to rise above a predetermined threshold, the control circuit decreases the gain of the VCA.

In a stereo 9100B/2, the outputs of the left and right VCAs are summed into a precision rectifier. To ensure identical timing characteristics in mono and stereo units, both the left and right rectifier inputs are driven from the output of the left (mono) VCA for mono operation.

The output of the rectifier feeds a proprietary timing module which computes a control voltage for the VCA based on the rectified L+R signal. The dB-linear output of this module drives the linear-scale BROADBAND AGC G/R meter.

Compressor attack and release time-constants are controlled by the program material when the TIME CONSTANT switch is set to MULTI. When the switch is set to SINGLE, OPTIMOD-AM uses a 200ms attack and a 3dB/second release.

If the input signal falls below the level set by the GATE THRESHold control, release is slowed and re-directed toward 10dB gain reduction (= 0 on the BROADBAND AGC G/R meter). This level is detected by a band-limited peak detector circuit followed by a comparator. The output of the comparator activates a switching FET (to enable gating) and lights the GATE indicator on the front panel.

Component-level description:

Although only the broad-band AGC VCA on Card #2 is described here, the following discussion of VCA operation applies to VCA circuitry throughout OPTIMOD-AM.

If used alone, one of the paired gain-control blocks would introduce considerable distortion. Therefore, the first of the two matched blocks (IC18a) is used as the feedback element in a high-quality operational amplifier (IC17). The second of the matched blocks (IC18b) is then driven by the pre-distorted output of IC17.

The output of IC17 is first attenuated by R5, R6, C2, and then applied to the input of the feedback element IC18a. The output of IC17 is pre-distorted as necessary to force the current output of IC18a to precisely and linearly cancel the audio input into the virtual ground summing junction of IC17. This same pre-distorted voltage is also connected to the input of IC18b. The output of IC18b is therefore an undistorted current, which is converted to a voltage in current-to-voltage converter IC16a, R12, R13, C4. The output of IC16a is the output of the VCA.

Because IC18a is in the feedback loop of IC17, the gain of the VCA is *inversely* proportional to the gain of IC18a. So, if the control current is applied to the control port of IC18a (through R7), the VCA will behave like a two-quadrant analog *divider*.

A fixed current is applied to the control port of IC18b through R10 to set the gain of IC18b. R10 is fed by a +1.2V source (R58, CR3, CR4), common to all VCAs on a card (the diodes provide temperature compensation).

Second-harmonic distortion is introduced by differential offsets in either IC18a or IC18b. This distortion is canceled by a nulling voltage applied directly to the input of IC18b by resistor network R4d, R8, R9.

If the VCA is not perfectly balanced, 'thumps' due to control current feedthrough can appear at the output. These are equivalent to multiplying the control current by DC. If the correct DC offset is applied to the VCA input, this equivalent DC multiplication can be nulled to zero, eliminating the thumps. An adjustable DC offset is provided by R4c, R2.

Frequency-compensation components R3, C1 prevent the VCA from oscillating supersonically.

Because the basic current-controlled gain is inversely proportional to the control current, it must be transformed into a gain that is proportional to the control voltage (in dB). This is done in exponential current converter IC21a and associated components.

IC11a, IC11e, and associated components form a log/antilog multiplier that multiplies the current flowing through R115 by the exponential of the voltage on the base of IC11a. The current gain of the multiplier increases as the voltage on the base of IC11a becomes more positive.

The exponential-converter transistors for all of the VCAs on Card #2 are in monolithic array IC11. One transistor within this array (IC11e) is connected to the emitters of all the other exponential-converter transistors to provide a common reference. This reference (approximately −0.6V) is produced by forcing a constant current through IC11e. The voltage across R115 is held at 15V by the feedback action of IC10a, which determines the current through

IC11e and thus its base-to-emitter voltage. C25 prevents IC10a from oscillating. CR7 protects IC11e from a reverse bias latch-up condition, which could zener IC11e's base-emitter junction and cause permanent damage.

The output current of the log/antilog multiplier appears at the collector of IC11a. Since it is the wrong polarity and level to correctly drive the control-current port of IC18a, it is applied to a current inverter (IC21a, Q1, R15, R16, C5) with a gain of 6.66×. A voltage proportional to the current output of IC11a is developed across R16, due to the feedback action of IC21a. C5 stabilizes IC21a against oscillations. Feedback forces IC21a's (–) and (+) inputs to the same voltage. Therefore, the voltage across R16 is the same as the voltage across R15, and current flows through R15 in proportion to the ratio between the values of R16 and R15. This current flows out of the (+) input line of IC21a into the emitter of Q1. Because Q1's base current is small compared to its emitter current, essentially the same current flows out of Q1's collector into the gain-control port of IC18a. Because Q1's base is grounded, its emitter sits at +0.6V. This forces both the (+) and (–) inputs of IC21a to sit at +0.6V also, ensuring correct bias voltage for IC11a's collector. CR1 protects Q1 from reverse base-emitter voltage, which could cause junction breakdown, leading to latch-up of the entire current-inverter circuit.

On Card #6, the sum of the left and right broad-band VCA outputs is applied to full-wave precision rectifier IC4a and associated components. This circuit adds twice the inverted output of a precision half-wave rectifier to its input. The rectifier output is integrated by a proprietary timing module, which produces a control voltage for the broad-band AGC VCAs on Card #2.

The threshold of compression is determined by R61 for the slow attack circuitry, regardless of the position of the TIME CONSTANT switch. The threshold for the fast attack circuitry (used only when the TIME CONSTANT switch is set to MULTI) is determined by R63.

When the MODE switch is set to PROOF, the proof bus is forced to +15V, and the thresholds of both the slow and fast attack circuits are raised by paralleling the threshold-determining resistors with resistors of lower value (R62 and R64). When the PROOF switch is set to OPERATE, the proof bus floats, and CR6 and CR7 isolate the circuitry from the proof bus.

The level-dependent gating is controlled by variable-gain amplifier IC12a and associated components. The low-frequency response of the gating level detector is rolled-off by C9; its high-frequency response is rolled-off by C8. Both roll-offs are at 6dB/octave. The output of IC12a is applied to peak detector (CR1, C10, R45), and the output of the peak detector is applied to comparator IC12b. The comparator threshold (and thus the threshold at which gating occurs) is determined by voltage divider R46, R47. Gating occurs when the output of IC12b goes negative, which lights the GATE indicator, and turns off the gate switching FET Q13 through CR3. When this occurs, the integration network within the module is disconnected from the main release circuit. Release is then determined by R48 and R49, which very slowly charge the release circuitry to a voltage corresponding to 10dB gain reduction. In non-gated conditions, the release time is determined by R50.

When the MODE switch is set to PROOF, the proof bus goes to +15V, forcing the input of IC12b positive and its output negative. This gates the broad-band AGC, forcing it to 10dB gain reduction.

7. Bass Equalizer

The 'quasi-parametric' bass equalizer provides control of the peak equalization frequency (70–110Hz), the amount of equalization (0-6dB), and the equalization bandwidth (Q = 0.3 to 1.4). Although adjusting the frequency or boost will change the fractional bandwidth, the controls are otherwise non-interacting. The output of the bass equalizer's dual-amplifier quasi-parametric bandpass resonator is summed with the unequalized signal in the main amplifier of the high-frequency equalizer.

Component-level description:

The output of second-order 'quasi-parametric' bandpass resonator IC9, R35, R36, R37, R38, R39, R40, R41, R43, R44, C11, C12 appears at the output of IC9a. To create peak boost, IC9's output is summed with the input signal of the resonator through R42 (input) and R34 (output). The amount of equalization is determined by the resonator input attenuator R35. The normal frequency response of the resonator at the output of IC9a is a bell-shaped curve centered at approximately 90Hz. The normal gain of the resonator from the wiper of R35 to the output of IC9a at the frequency of maximum gain is 6.02dB.

Because the operation of the resonator can only be justified mathematically, further discussion of it is beyond the scope of this manual.

8. High-frequency Equalizer

Located on Cards #4 and #5

To provide accurate equalization of a typical AM radio to a frequency determined by the HF EQ controls, the patented high-frequency equalizer produces an 18dB/octave shelving boost. A special filter introduces a controlled amount of positive feedback around an opamp to control the amount of boost.

The essential tuning elements are located in a plug-in resistor array. Several different color-coded arrays are available to tailor OPTIMOD-AM's high-frequency equalization to your particular needs.

Component-level description:

High-frequency equalization is realized by applying an adjustable amount of frequency-selective positive feedback around IC5a. Selectivity is provided by active filter IC5b and associated components. Tuning elements for the active filter are located in module A1 to permit simple re-tuning of the equalizer for different broadcast environments.

The amount of high-frequency equalization is adjusted by setting the amount of positive feedback with HF EQ control R46.

9. Sum-and-difference Matrix

Stereo (9100B/2) units only. Located on Card #5

The sum-and-difference matrix transforms the equalized left and right channel signals into sum-and-difference (L+R and L–R) signals.

The output of the left program equalizer (on Card #4) is routed to the matrix on Card #5. The L+R output of the matrix is then returned to Card #4. (In mono 9100B/1 units, the matrix is bypassed with jumper A on Card #4.)

Component-level description:

The sum signal is created by inverting summing amplifier IC10a, R50, R51, R52. The difference signal is created by differential amplifier IC10b, R53, R54, R55, R56.

The rather obscure routing of signals back and forth between Cards #4 and #5 is to permit Cards #4 and #5 to be swapped for troubleshooting (see Section 5).

10. Six-band Limiter, Distortion-canceling Multi-band Clipper

(Overview) USA Patent #4,412,100

Because the six-band limiter is so intimately connected with the multi-band clipper, they will be discussed together. Each limiter/clipper circuit is discussed in detail following these general comments.

OPTIMOD-AM incorporates Orban's patented six-band limiter and distortion canceling multi-band clipper.

The signal for each channel is first divided into six frequency bands by a pre-compressor crossover. Each crossover filter then drives its own compressor/limiter, which in turn drives a clipper followed by a post-compressor filter. The characteristics of the pre- and post-compressor filters enable a very flat (±0.5dB) final summation of the bands.

The first-order filtered distortion induced by clipping in the upper four bands is derived by subtracting the clipper's output from its input, and then filtering this distortion signal with a filter identical to the post-crossover filter. The sum of these filtered distortion signals from the upper four bands is passed through a 2kHz low-pass filter.

Meanwhile, the clipped, filtered sum of all of the bands is passed through a phase-corrected 12kHz filter with a delay that matches that of the 2kHz low-pass filter. By then summing the outputs of the 12kHz and 2kHz filters, clipper-induced distortion below 2kHz (the average "flat" passband of an AM radio) is sharply canceled.

This approach reduces distortion much better than could simple first-order filtering after the clippers — effective selectivity is about 36dB/octave. The cancelation is particularly effective in eliminating the 'ffff' sound characteristic of heavily clipped sibilance.

It should be noted that it is normal for *sine waves* to modulate less than 100% when the PROOF switch is set to OPERATE. There are two principal reasons for this:

- Some headroom is left between the threshold of the multi-band distortion-canceling clipper and the threshold of the subsequent safety clipper to accommodate the distortion corrector signal. No distortion corrector signal is produced with sine waves, so the headroom is not used and full 100% modulation does not occur.
- Sine waves have a very low peak-to-average ratio and a high loudness potential compared to program material of identical peak levels. The audio processing, in order to maintain natural sound quality, pushes sine waves down in level as it would any other similar program material with low peak-to-average ratio. In general, any audio processor which produces 100% modulation on sine waves tends to sound somewhat unnatural because it ignores this psychoacoustic factor.

11. Pre-compressor Crossovers

Located on Cards #4 and #5

The 150Hz (band 1) low-pass crossover is a second-order 420Hz low-pass filter cascaded with a second-order 150Hz low-pass filter.

The 420Hz (band 2) bandpass crossover is a second-order 420Hz low-pass filter cascaded with a third-order 420Hz high-pass filter.

The 700Hz (band 3), 1.6kHz (band 4), and 3.7kHz (band 5) bandpass crossovers each consist of two cascaded, second-order stagger-tuned bandpass filters.

The 6.2kHz (band 6) high-pass crossover is a second-order 6.2kHz high-pass filter.

Bands 3, 4, 5, and 6 are fed from a first-order all-pass filter, which provides phase correction for the crossover summation.

Component-level description:

All filters are built with second-order sections of the type found in any modern text on active filter design (see, for example, chapter 6 of Wong and Ott: *Function Circuits*. McGraw-Hill, New York, 1976). Some filters are basically negative-feedback filters of the 'multiple feedback' type; others are positive-feedback 'Sallen and Key' type filters. The two types are mixed as necessary to achieve inverting (negative feedback) or non-inverting (positive feedback) responses.

12. Six-band Limiter VCAs

Bands 1,3,5 located on Card #2; bands 2,4,6 located on Card #3

The VCAs in bands 1–5 have a potential gain reduction range of 25dB. To accommodate the extreme high-frequency pre-emphasis available, the available gain reduction range of band 6 is 30dB.

(To facilitate conversion to stereo operation, mono 9100B/1 units are equipped with factory-aligned pairs of VCAs. In the 9100B/1, certain ICs have been removed to prevent potential oscillation of the VCAs due to unterminated inputs.)

Component-level description:

See page 6-13 for a discussion of VCA operation.

13. Six-band Limiter Control

Located on Card #6

The output of each band's VCA feeds a voltage divider which, in turn, feeds a dual comparator IC. If the output of the voltage divider exceeds the threshold set by the CLIPPING control (±0.5V to ±1.0V), the comparator will produce an output pulse. This pulse is smoothed by the timing module to produce a control voltage that reduces the gain of the VCA. Therefore, the drive level to the clippers following the compressors and pre-emphasis/high-frequency limiters is determined by the CLIPPING control. Because the CLIPPING control simultaneously adjusts all comparator thresholds, it governs the average VCA output level.

This proprietary timing circuitry is located within sealed modules. It provides: 1) peak limiting with very fast recovery time for transient material; 2) slower compression with a recovery time that is a function of gain reduction; and, 3) recovery delay for smoothing of the gain control voltage to avoid low-frequency distortion even with fast release times.

The timing circuits process the signal in logarithmic form, and have low-impedance outputs. They drive exponential converters which provide control-current outputs for their respective VCAs.

Component-level description:

Because the control circuits for all six bands are identical (except for component values), only the control circuit for the 150Hz band (band 1) will be discussed in detail.

The output of the band 1 VCA is applied to voltage divider R1, R2. If the output of voltage divider R1, R2 exceeds the comparator threshold voltage generated by IC8 and associated circuitry, the NPN output transistor within IC1c, IC1d turns on, also switching Q2 on. (R5 determines Q2's collector current, which in turn determines the attack time.) Two factors thus determine the threshold of limiting : 1) the loss in voltage divider R1, R2 (the more loss, the higher the voltage at the VCA output before IC1c, IC1d turns on); and, 2) the threshold voltage applied to IC1c, IC1d by CLIPPING control R65. R65 adjusts this voltage from ±0.5 to ±1.0V — this changes the threshold of limiting, and thus the average output level of the band VCAs.

The timing module integrates Q2's collector current and produces a voltage which is buffered by unity-gain FET-input opamp IC3a. The output of IC3a is a dB-linear control voltage which determines the gain of the band VCA (in dB).

14. Post-compressor Crossover, Clippers, and Distortion-cancelation

Located on Cards #7 and #10

The upper four bands are treated differently than the bottom two bands.

The objectionable distortion generated by the upper four (high-frequency) bands is, by and large, difference-frequency intermodulation *below* the frequency of the band in question. This is because *harmonic distortion* caused by clipping is radically rolled off by the 'average' radio, which is only flat to 2kHz. This roll-off also reduces the level of most of the fundamentals in the upper four bands, effectively amplifying the effect of the difference-frequency IM — which is *not* rolled off.

Difference-frequency IM due to clipping is canceled below 2kHz by a patented (USA #4,208,548) feedforward distortion-canceling sidechain. The output of each of the four upper bands is applied to two identical filters (one inverting and one non-inverting) with 6dB/octave slopes. The 6.2kHz band filter is high-pass; the others are bandpass.

A clipper is located before the inverting filter, so that the inverting filter filters the clipped signal, somewhat reducing out-of-band clipper-induced distortion.

The outputs of the inverting and non-inverting filters are added in the distortion-canceling summing amp. If no clipping occurs, the outputs of the inverting and non-inverting filters will cancel, and there will be no output from the distortion-canceling summing amp. If clipping does occur, the distortion-canceling summing amp's output will represent the difference between the clipper's input and output as filtered by the inverting filter. This difference signal is the distortion added by the clipper (filtered through the 6dB/octave filter).

Since the upper four bands are all processed by the distortion-canceling summing amp, the output of this amplifier represents the sum of the filtered clipper-induced distortion produced by the four clippers in these bands. This signal is applied to the distortion-canceling filter, a 2kHz low-pass filter with constant delay.

Meanwhile, the outputs of just the inverting filters (containing the clipped, filtered outputs of the upper four bands) are summed into the band summation amplifier. The output of this amplifier is applied to the input of the 12kHz phase-linear low-pass filter.

The outputs of the 12kHz filter and 2kHz filter are summed. If only one band is passing signal, the clipper-induced distortion component which that band contributes to the 2kHz filter's output is equal to, and out-of-phase with, the same distortion component in the 12kHz filter's output. Thus, the distortion component is canceled by better than 30dB within the 2kHz bandwidth of the distortion-canceling filter. Because the 12kHz and 2kHz filters and the summation process are all linear, superposition holds and the distortion component in each of the four top bands is canceled — even when more than one band is active.

The two low-frequency bands are not processed by the distortion-cancelation sidechain because the objectionable distortion in these bands is not IM, but rather *harmonic* distortion *above* the frequency range of the bands. Simple low-pass filtering of the clipped signal can therefore be used to reduce distortion.

The 150Hz band's VCA is forced to clip slightly above the threshold of limiting to remove overshoots. This clipped signal is applied to a pair of cascaded, 6dB/octave low-pass filters before it is summed with the other bands in the band summation amplifier.

A clipper is located between the first and second filters. The output of the 420Hz band is applied to this clipper, and then routed through the second low-pass filter to the band summation amplifier. The clipper therefore clips the *sum* of the 420Hz band and the clipped, filtered 150Hz band. The clipper constrains this low-frequency sum to several dB below 100% modulation, thus preventing excessive IM between the low frequencies and high frequencies in the final safety clipper.

Component-level description:

Band 5 (3.7kHz) is used as an example of a typical high-frequency band in the following.

The output of band 5's VCA is applied to 6dB/octave high-pass filter R22, R24, C13. Clipper diodes (CR7, CR8) embedded between R22 and R24 clip the output of the band VCA before it is applied to the high-pass filter. The clipped signal is also low-pass filtered by the feedback action of R25, C14 in association with IC2a (which inverts the signal). The output of IC2a is therefore the clipped signal, passed through a bandpass (high-pass + low-pass) filter with 6dB/octave skirts.

The output of band 5's VCA is also applied to passive RC bandpass filter R23, R26, R27, C11, C12. It can be shown that the frequency response of this filter is identical to the frequency response of IC2a and its associated filters. The output of this non-inverting passive filter is summed (through R27) with the output of IC2a (through R29) into the distortion-canceling summing amp, IC6a's summing bus. When clippers CR7 and CR8 are non-conductive, total cancelation occurs (within the limitation of component tolerances), and no signal appears on the summing bus. When the clippers conduct, all of the signal is canceled except the distortion added by the clipping process, as filtered by IC2a and associated components.

The output of IC2a is also summed (through R28) into the band summation amplifier, IC3a's summing bus. To preserve the proper asymmetry in all bands when the multi-band clippers are operated asymmetrically, the low-frequency bands are summed into IC3a in a *non-inverting* manner (since no inversion occurs after clipper diodes CR1, CR2, and inversion occurs after all other clipper diodes in IC1 and IC2). The feed to the top four bands is also inverted in the pre-compressor crossover so that all bands sum in IC3a with correct polarity.

The output of band 1's VCA is low-pass filtered by R1, R3, C1, and then mixed with the output of band 2 through R2. The sum is clipped by CR1, CR2, and low-pass filtered again (through R4, R5, C2) before being applied to the (+) input of band summation amplifier IC3a.

The output of IC3a feeds passive, fifth-order, elliptical filter R37, R38, L1, L2, C17, C18, C19, C20, C21, C22, C23. The output of this filter is buffered by inverting shelving filter IC3b, R39, R40, C24. (Flat response is later restored by a complementary shelf produced by IC9b.)

The output of IC3b feeds a pair of second-order all-pass filters (IC4a, IC4b, and associated components). Each of these filters has a flat magnitude response and a phase response which varies with frequency. The phase response is designed to equalize the phase response of the 12kHz low-pass filter to produce approximately constant time delay from 0 to 12kHz, thus minimizing overshoots in the 12kHz filter.

Meanwhile, the output of distortion-canceling summing amp IC6a feeds a 2kHz low-pass filter (R66, R67, R68, L3, C35, A1) with amplitude and phase response that match those of the passive 12kHz low-pass filter, shelving filter IC3b, and phase corrector IC4 through 2kHz. The output of the 2kHz distortion-canceling low-pass filter is summed with the output of the main phase corrector in summing shelving filter IC9b and associated components.

The output of IC9b is the distortion-canceled sum of the six bands. Its bandwidth is limited to 12kHz. It contains substantial overshoots which are ordinarily removed in the following safety clipper. In stereo 9100B/2 units, the IC9b's output is in L+/L–R format. Jumpers on Card #9 of the 9100B/2 permit placing the de-matrix circuit before the Accessory Port so that the exciter can be fed audio in L/R format.

15. 200Hz High-pass Filter, Low-pass Filter, Stereo Enhancer

Stereo 9100B/2 units only. Located on Card #1S10

The output of the six-band limiter and distortion-canceling multi-band clipper is applied to an optional, jumper-selected 200Hz L–R high-pass filter, which protects the low frequency part of the L–R channel so it can be used for telemetry or low-frequency SCA.

The signal is then low-pass filtered to minimize interference with other AM stations. One of three cut-off frequencies can be selected: the 10kHz low-pass filtering recommended by the National Radio Systems Committee (NRSC), 12kHz, or 5kHz. The low-pass filters can be preset with jumpers, and switched by OPTIMOD-AM's day/night logic.

An optional single-channel limiter limits negative peak modulation to 75%, as required by some exciters. The optional stereo enhancer increases the level of the L–R signal up to 6dB above that of the L+R signal.

Component-level description:

The L+R signal enters a third-order all-pass filter (IC14 and associated components). The magnitude response of this filter is very flat, but its phase response changes as a function of frequency. Its gain is unity. It is designed to accurately phase-match the high-pass filter in the L–R channel above 190Hz.

The high-pass filter consists of IC2 and associated components. It is a fifth-order filter with a deep notch at 104.5Hz and unity gain. It ideally has 0.1dB frequency response irregularity in its passband, which is above 190Hz. (10Hz was left as a guardband to assure that separation specifications would be met at 200Hz under normal tolerances.)

Both the all-pass and high-pass filters are non-inverting at high frequencies. (At frequencies below approximately 500Hz, their phase response changes rapidly as a function of frequency, so it cannot be strictly said that they are 'inverting' or 'non-inverting'.)

Fig. 6-1 shows the ideal separation; Fig. 6-2 shows the ideal frequency response of the high-pass filter.

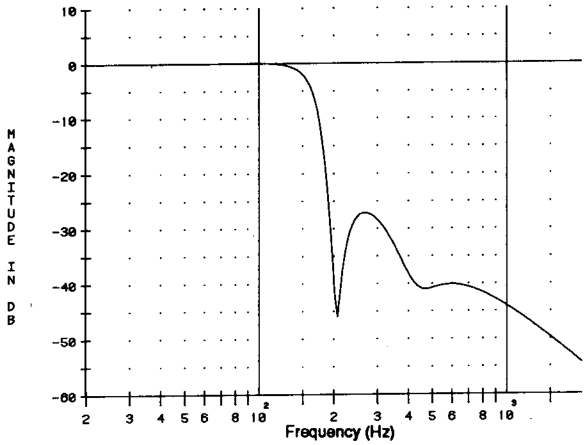

Fig. 6-1: Ideal Separation with 200Hz High-pass Filter

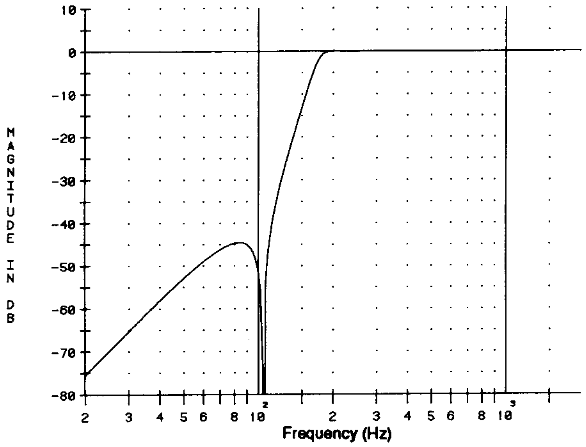

Fig. 6-2: High-pass Filter Frequency Response

The 5kHz low-pass filter consists of two matched, unity-gain, phase-corrected, fifth-order Chebychev filters with 0.1dB frequency response irregularity and a −0.1dB bandwidth of 5.0kHz. One filter is for the L+R channel and one is for the L−R channel. (Only the L+R channel is discussed; the L−R channel is identical.)

IC13a and associated components form a third-order non-inverting filter with a gently rolled-off frequency response. The fifth-order filter's frequency response shaping is completed by IC11b and associated components, which form a second-order inverting filter when the circuit path is completed by placing DAY jumper H or NIGHT jumper F in the 5kHz position. (Jumper G selects DAY and jumper E selects NIGHT low-pass filtering for the L−R channel.) IC13b and associated components form a phase corrector, which is an all-pass filter with flat magnitude response and frequency-dependent phase response. This filter adds delay as necessary to make the delay of the entire filter approximately constant with frequency, thereby minimizing overshoot.

DAY/NIGHT switching is effected by very simple logic. Pin T on Card #1S10 is low (−15V) when OPTIMOD-AM is in NIGHT mode, and high (ground) when it is in DAY mode. The logic level at pin T drives JFET Q1 directly. Q6 inverts the logic and drives Q2. Q1 and Q2 are on when their gates are at ground, and off when their gates are at −15V. Thus Q2 turns on in NIGHT mode and connects jumper F into the circuit path, while Q1 turns on in DAY mode, and connects jumper H into the circuit path.

The 10kHz low-pass filter (located on Card #1S10's auxiliary card) consists of a pair of overshoot-compensated low-pass filters — one for L+R and one for L−R. Each filter is made up of two filters in series, with embedded clippers. (Only the L+R filter is specifically described in the following.)

Entering the filter, the signal encounters clipper CR1, CR2, which provides main peak control. After buffering by IC1, the clipped signal is applied to the first 10kHz filter (IC2, IC3, IC4 and associated components). This filter is very steep, and removes the harmonics introduced by the clipping in CR1, CR2, as well as any significant program energy above 10kHz.

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

Each FDNR resonates with a series resistor to create a notch in the frequency response of the filter. This is analogous to a series LC circuit to ground. The notches are located in the 'stopband' (beyond approximately 10.05kHz). The circuit associated with IC2 produces a notch at 10.65kHz ±4%. The circuit associated with IC3 produces a notch at 12.00kHz ±4%. The circuit associated with IC4 is tuned by R17 to produce a notch at precisely 10.10kHz to ensure that the filter's response falls accurately above 10kHz, and that NRSC specifications are met.

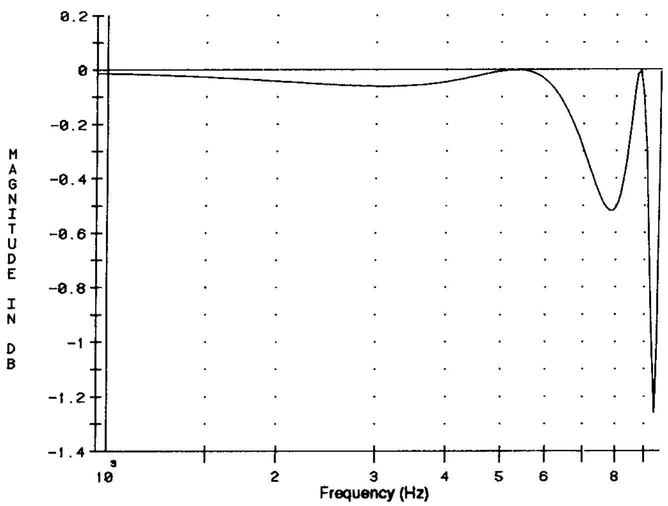

Fig. 6-3: Response of the First 10kHz Low-Pass Filter in the Passband
Card #1S10

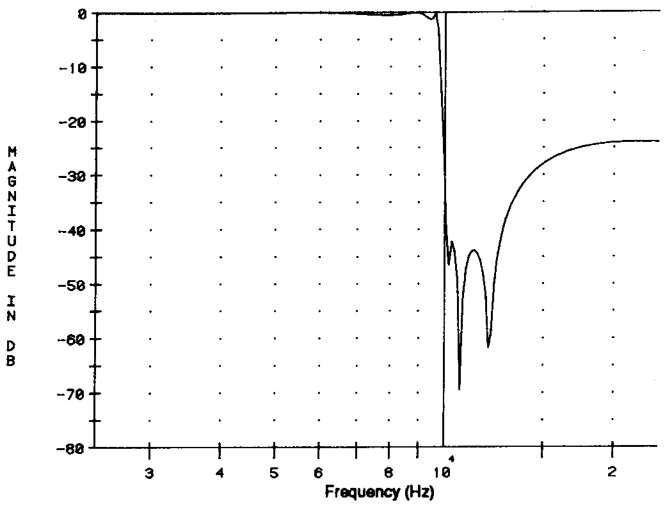

Fig. 6-4: Response of the First 10kHz Low-Pass Filter in the Passband and Stopband Card #1S10

To avoid possible clipping, the signal is attenuated 5dB with voltage divider R3, R4 before being applied to the filter. This gain is made up by IC5a to restore unity gain at low frequencies. All-pass delay corrector IC5b adds frequency-dependent delay to the first filter as necessary to make its time delay more constant with frequency, thereby minimizing overshoot.

Any residual overshoot is clipped in IC6b, and then the signal is applied to second 10kHz filter IC6a, IC7a. The primary purpose of this second filter is to remove harmonics caused by clipping in IC6b. Finally, all-pass delay corrector IC7b adds delay as necessary to make the delay of the second filter more constant with frequency.

Fig. 6-5 shows the normal frequency response of the part of the second filter associated with IC6a, while Fig. 6-6 shows the normal frequency response of the part of the second filter associated with IC7a. Fig. 6-7 shows the overall frequency response of the second filter.

The normal frequency response of each all-pass delay corrector (IC5b and IC7b) is flat, although each has a frequency-dependent phase shift. IC15a and IC15b and associated components act as servos to eliminate DC offset at the output of IC7b and IC14b, respectively.

Fig. 6-8 shows the normal power spectrum measured at OPTIMOD-AM's output with the 10kHz filter strapped in and stereophonic program material applied to OPTIMOD-AM's input. The measurement (made with an 801-line FFT spectrum analyzer operated in 'peak hold' mode over a 20-minute observation period with OPTIMOD-AM controls at the normal recommended settings) verifies that NRSC power bandwidth specifications are met by the system.

The 10kHz filters can be strapped into the circuit with jumpers H and F. These jumpers can also be configured to bypass all filters on Card #1S10, retaining only the 12kHz filtering provided elsewhere in OPTIMOD-AM.

Both L+R and L−R filters are followed by clippers IC11a and IC3a, which duplicate the function of the safety clippers on Cards #7 and #10, as well as essentially duplicating the clippers within the 10kHz filter. However, they are necessary when Card #1S10 is operated at 5kHz or 12kHz bandwidth because the subsequent single-channel limiter must see properly controlled L+R and L–R peak levels to perform correctly.

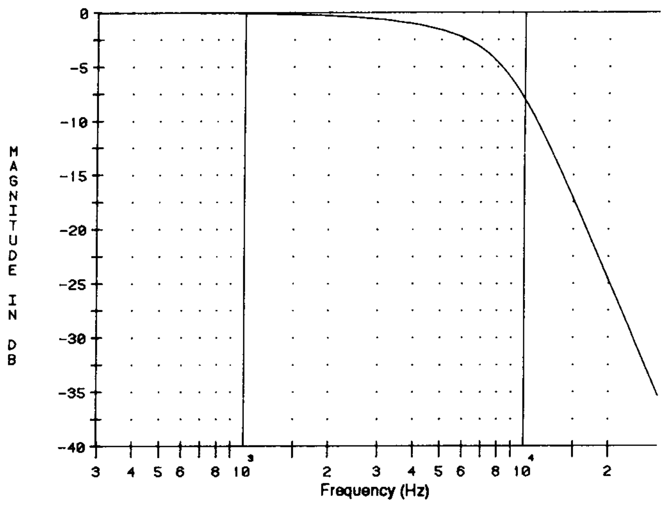

Fig. 6-5: Normal Frequency Response of that part of the Second 10kHz Filter associated with IC6a on Card #1S10

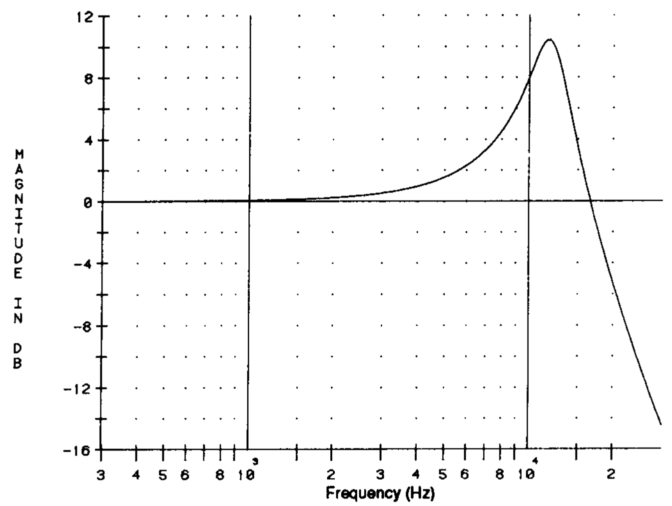

Fig. 6-6: Normal Frequency Response of that part of the Second 10kHz Filter associated with IC7a on Card #1S10

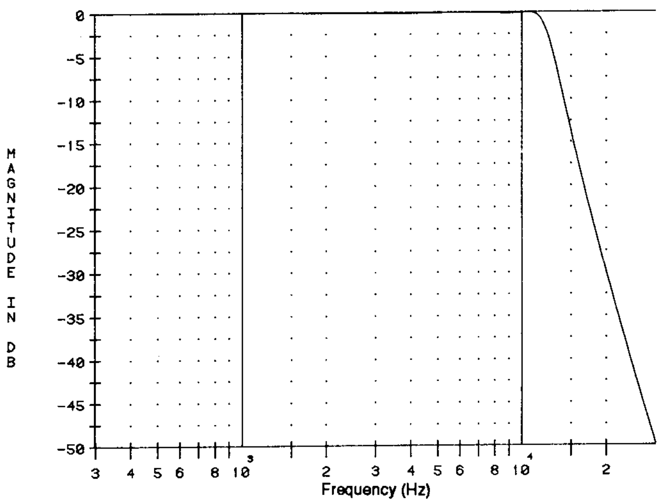

Fig. 6-7: Overall Frequency Response of the Second 10kHz Filter Card #1S10

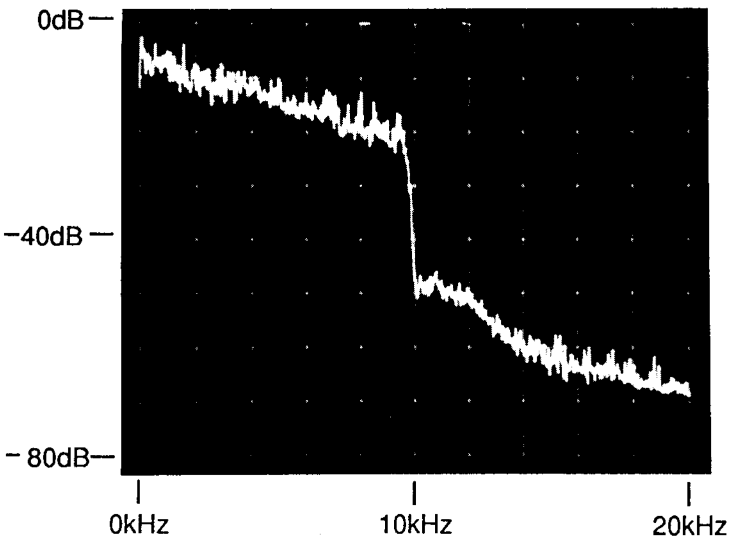

Fig. 6-8: Normal Output Power Spectrum of a Stereo OPTIMOD-AM with 10kHz Filter Card #1S10

To effect single-channel limiting and stereo enhancement, the L–R signal is applied to a voltage-controlled amplifier using junction FET Q5 as the gain-control element. To prevent distortion, the L–R signal is attenuated by voltage divider R53, R45, R56, R85, R86 before being applied to the FET. SEPARATION trimmer R45 permits precise adjustment of the loss in this attenuator. STEREO ENHANCE trimmer R85 permits the user to increase the L–R level by as much as 6dB to increase apparent separation and stereo loudness.

Normally Q5 is biased off with a negative voltage on its gate as provided by FET BIAS trimmer R39 through resistors R49, R50, and R52. Control circuitry consisting of comparators IC6 and IC9 and associated integration circuitry CR3, CR4, CR5, CR8, CR9, C23, C24, R50, R51 produces a positive-going control voltage which turns Q5 on and reduces L−R gain as necessary to avoid excessive clipping in single-channel clippers CR7 and CR11. C25 and R55 provide a distortion-nulling audio voltage to the FET gate. IC10b and associated components form a servo integrator that eliminates DC offset from the output of non-inverting buffer amplifier IC7. De-matrices IC8b and IC5b extract −L and −R (inverted L and R channels) from the L+R and processed L−R . The control circuitry for the L−R limiter monitors the negative peak levels of the −L and −R signals (corresponding to negative-going envelope modulation), and controls these levels by feedback to the L−R VCA as described above. After resistive attenuation, the −L and −R signals are clipped asymmetrically by CR7 and CR11. The clipping thresholds correspond to −75% L and R modulation.

Because L and R average levels are controlled by gain reduction in the L−R channel only, mono reproduction is unaffected by the action of Q5. Its only effect is to momentarily reduce stereo separation — an effect to which the ear is relatively insensitive, particularly when it occurs quickly.

Matrices IC8a and IC5a (and associated resistors) extract L+R and L−R from the peak-controlled −L and −R signals. Gains are chosen so that the overall input/output gain of the single-channel limiter subsystem is unity when no gain reduction is occurring.

The reference voltage for comparators IC6 and IC9 ordinarily is −5.73VDC as determined by R67 and R68. When OPTIMOD-AM's MODE switch is set to OPERATE, CR10 is reverse-biased. However, when the MODE switch is set to PROOF, the ±4.1V clipping reference voltages increase to approximately ±14VDC. This turns CR10 on, pulling the threshold of the comparators up approximately 7dB and ensuring that no gain reduction will occur for any reasonable signal level.

The outputs of Card #1S10 are applied to the clippers on Cards #7 and #10 when the MODE switch is set to OPERATE. The thresholds of these clippers are matched within a few percent to the thresholds of the various clippers on Card #1S10. Thus no significant clipping occurs in the clippers on Cards #7 and #10 when Card #1S10 is installed, and the clippers do not introduce out-of-band harmonics that could cause interference to adjacent stations.

16. Low-pass Filter

Mono 9100B/1 units only. Located on Card #1F10

The output of the six-band limiter and distortion-canceling multi-band clipper is applied to a low-pass filter to minimize interference with other AM stations. One of three cut-off frequencies can be selected: the 10kHz low-pass filtering recommended by the National Radio Systems Committee (NRSC), 12kHz, or 5kHz. The low-pass filters can be preset with jumpers, and switched by OPTIMOD-AM's day/night logic.

Component-level description:

The 5kHz low-pass filter is a unity-gain, phase-corrected, fifth-order Chebychev filter with 0.1dB frequency response irregularity and a −0.1dB bandwidth of 5.0kHz.

IC8a and associated components form a third-order non-inverting filter with a gently rolled-off frequency response. The fifth-order filter's frequency response shaping is completed by IC9a and associated components, which form a second-order inverting filter when the circuit path is completed by placing DAY jumper B or NIGHT jumper A in the 5kHz position. IC8b and associated components form a phase corrector, which is an all-pass filter with flat magnitude response and frequency-dependent phase response. This filter adds delay as necessary to make the delay of the entire filter approximately constant with frequency, thereby minimizing overshoot.

DAY/NIGHT switching is effected by very simple logic. Pin T on the card is low (−15V) when OPTIMOD-AM is in NIGHT mode, and high (ground) when it is in DAY mode. The logic level at pin T drives JFET Q2 directly. Q1 inverts the logic and drives Q3. Q2 and Q3 are on when their gates are at ground, and off when their gates are at −15V. Thus Q3 turns on in NIGHT mode and connects jumper A into the circuit path, while Q2 turns on in DAY mode, and connects jumper B into the circuit path.

The 10kHz low-pass filter is an overshoot-compensated low-pass filter, consisting of a first and second filter in series, with embedded clippers.

The signal enters the filter system and encounters clipper CR1, CR2, which provides main peak control for the signal. After buffering by IC1a, the clipped signal is applied to the first 10kHz filter IC2, IC3, IC4 (and associated components). This filter is very steep, and removes the harmonics introduced by the clipping in CR1, CR2, as well as any significant program energy above 10kHz.

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

Each FDNR resonates with a series resistor to create a notch in the frequency response of the filter. This is analogous to a series LC circuit to ground. The notches are located in the 'stopband' (beyond approximately 10.05kHz). The circuit associated with IC2 produces a notch at 10.65kHz ±4%. The circuit associated with IC3 produces a notch at 12.00kHz ±4%. The circuit associated with IC4 is tuned by R39 to produce a notch at precisely 10.10kHz to ensure that the filter's response falls accurately above 10kHz, and that NRSC specifications are met.

To avoid possible clipping, the signal is attenuated 5dB with voltage divider R24, R25 before being applied to the filter. This gain is made up by IC5a to restore unity gain at low frequencies.

All-pass delay corrector IC5b adds frequency-dependent delay to the first filter as necessary to make its time delay more constant with frequency, thereby minimizing overshoot.

Any residual overshoot is then clipped in IC6a, and then the signal is applied to second 10kHz filter IC6b, IC7a. The primary purpose of this second filter is to remove harmonics caused by clipping in IC6a.

Finally, all-pass delay corrector IC7b adds delay as necessary to make the delay of the second filter more constant with frequency.

Fig. 6-11 shows the normal frequency response of the part of the second filter associated with IC6b, while Fig. 6-12 shows the normal frequency response of the part of the second filter associated with IC7a. Fig. 6-13 shows the overall frequency response of the second filter.

The normal frequency response of each all-pass delay corrector (IC5b and IC7b) is flat, although each has a frequency-dependent phase shift. IC10b and associated components act as a servo to eliminate DC offset at the output of IC9b.

Fig. 6-14 shows the normal power spectrum measured at OPTIMOD-AM's output with the 10kHz filter strapped in and bright program material applied to OPTIMOD-AM's input. The measurement (made with an 801-line FFT spectrum analyzer operated in 'peak hold' mode over a 20-minute observation period with OPTIMOD-AM controls at the normal recommended settings) verifies that NRSC power bandwidth specifications are met by the system.

The 10kHz filters can be strapped into the circuit with jumpers A and B. These jumpers can also be configured to bypass all filters on Card #1F10, retaining only the 12kHz filtering provided elsewhere in OPTIMOD-AM.

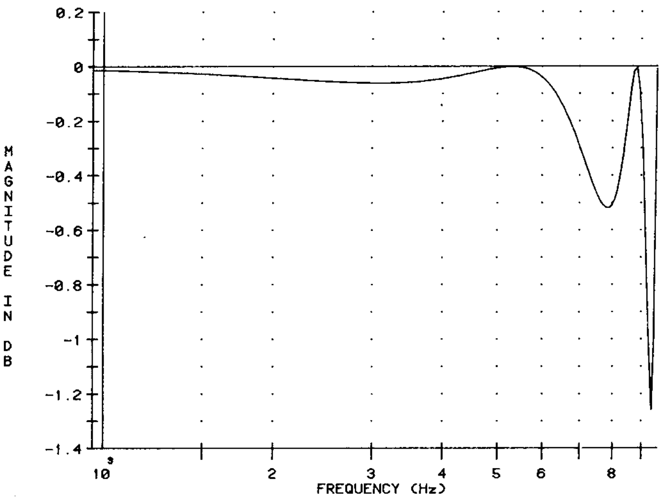

Fig. 6-9: Response of the First 10kHz Low-Pass Filter in the Passband
Card #1F10

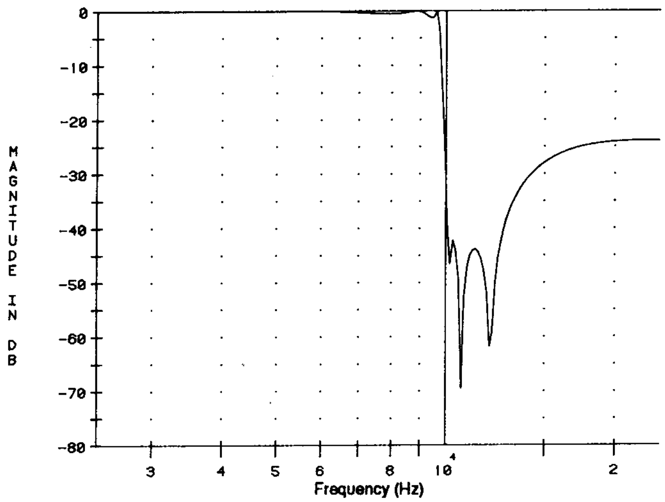

Fig. 6-10: Response of the First 10kHz Low-Pass Filter in the Passband and Stopband
Card #1F10

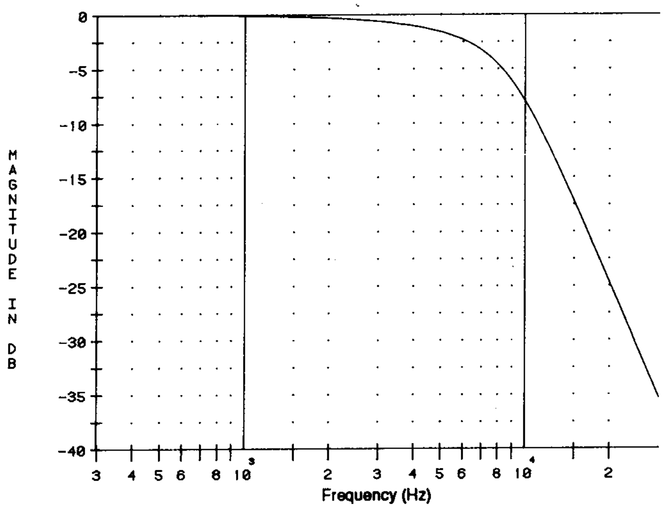

Fig. 6-11: Normal Frequency Response of that part of the Second 10kHz Filter associated with IC6b on Card #1F10

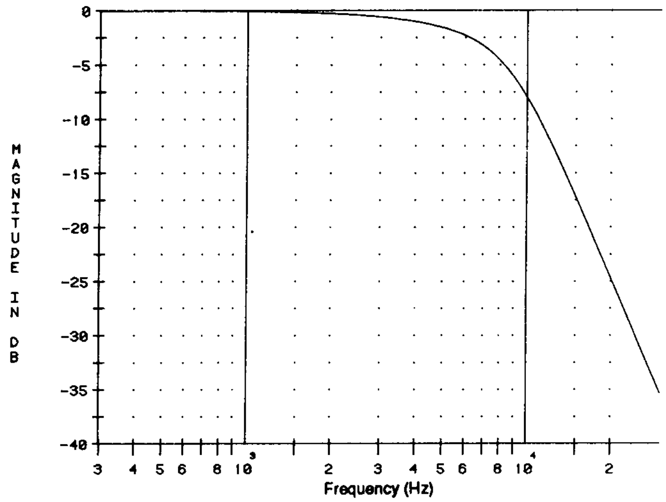

Fig. 6-12: Normal Frequency Response of that part of the Second 10kHz Filter associated with IC7a on Card #1F10

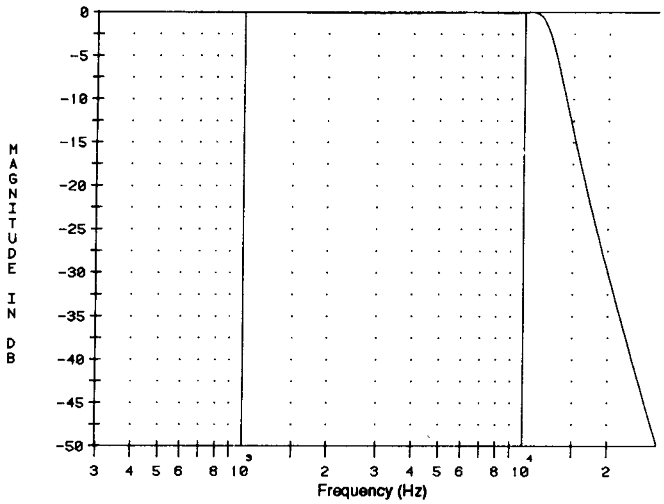

Fig. 6-13: Overall Frequency Response of the Second 10kHz Filter Card #1F10

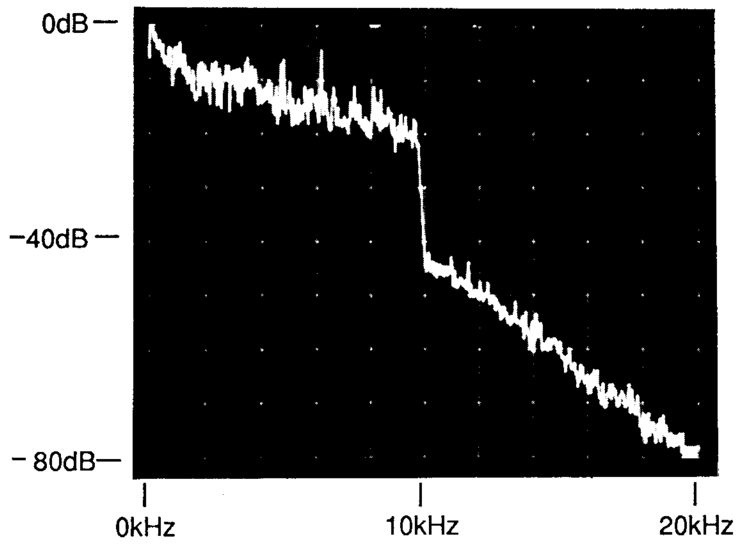

Fig. 6-14: Normal Output Power Spectrum of a Mono OPTIMOD-AM with 10kHz Filter Card #1F10

17. Low-pass Filter

Optional (mono 9100B/1 units only). Located on Card #1F4.5

The output of the six-band limiter and distortion-canceling multi-band clipper is applied to a 4.5kHz low-pass filter (required in some countries). One of two cut-off frequencies can be selected: 4.5kHz or 12kHz. The low-pass filter can be preset, or can be switched by OPTIMOD-AM's day/night logic. Card #1F4.5 replaces Card #1F10.

(4kHz, 5kHz, 5.5kHz, and 6kHz low-pass filters are available upon special order.)

Component-level description:

Upon special order, this low-pass filter is also available with a cut-off frequency of 4.0kHz, 5.0kHz, 5.5kHz, or 6.0kHz (on Cards #1F4.0, #1F5.0, #1F5.5, or #1F6.0, respectively). The cut-off frequency is clearly indicated on each card. If you have a low-pass filter card with one of the alternative cut-off frequencies, just substitute the name and cut-off frequency of that card for 'Card #1F4.5' and '4.5kHz' in the following.

The 4.5kHz overshoot-compensated low-pass filter consists of a first and second filter in series, with embedded clippers.

Clipper CR1, CR2 provides main peak control for the signal. After buffering by IC1a, the clipped signal is applied to the first 4.5kHz filter (IC2, IC3, IC4 and associated components). This very steep filter removes the harmonics introduced by the clipping in CR1, CR2, as well as any significant program energy above 4.5kHz.

The first filter is an active RC analog of a passive LC ladder filter, realized by resistors, capacitors, and frequency-dependent negative resistors (FDNRs).

An FDNR is realized with a dual opamp, three resistors, and two capacitors. When the passive LC filter is transformed into an active RC filter, inductors become resistors, resistors become capacitors, and capacitors become FDNRs.

Each FDNR resonates with a series resistor to create a notch in the frequency response of the filter. This is analogous to a series LC circuit to ground. The notches are located in the 'stopband' (beyond approximately 5.0kHz). The circuit associated with IC2 produces a notch at 8.033kHz ±4%. The circuit associated with IC3 produces a notch at 5.052kHz ±4%. The circuit associated with IC4 produces a notch at 5.039kHz ±4%.

To avoid possible clipping, the signal is attenuated 7dB with voltage divider R24, R25 before being applied to the filter. This gain is made up by IC5a to restore unity gain at low frequencies. All-pass delay corrector IC5b adds frequency-dependent delay to the first filter as necessary to make its time delay more constant with frequency, thereby minimizing overshoot. Any residual overshoot is then clipped in IC6a, and then the signal is applied to second 4.5kHz filter IC6b, IC7a. The primary purpose of this second filter is to remove harmonics caused by clipping in IC6a. Finally, all-pass delay corrector IC7b adds delay as necessary to make the delay of the second filter more constant with frequency.

Fig. 6-17 shows the normal frequency response of the part of the second filter associated with IC6b, while Fig. 6-18 shows the normal frequency response of the part of the second filter associated with IC7a. Fig. 6-19 shows the overall frequency response of the second filter.

The normal frequency response of each all-pass delay corrector (IC5b and IC7b) is flat, although each has a frequency-dependent phase shift. IC10b and associated components act as a servo to eliminate DC offset at the output of IC9b.

Fig. 6-20 shows the normal power spectrum measured at OPTIMOD-AM's output with the 4.5kHz filter strapped in and bright program material applied to OPTIMOD-AM's input. The measurement (made with an 801-line FFT spectrum analyzer operated in 'peak hold' mode over a 20-minute observation period with OPTIMOD-AM controls at the normal recommended settings) verifies that the system conforms to CCIR and EBU recommended practice regarding occupied bandwidth — without need for further low-pass filtering in the transmitter.

The 4.5kHz filter can be strapped into the circuit with jumpers A and B. These jumpers can also be configured to bypass the 4.5kHz filter, retaining only the built-in 12kHz (or 4.5kHz) filtering provided elsewhere in OPTIMOD-AM.

DAY/NIGHT switching is effected by very simple logic. Pin T on the card is low (−15V) when OPTIMOD-AM is in NIGHT mode, and high (ground) when it is in DAY mode. The logic level at pin T drives JFET Q2 directly. Q1 inverts the logic and drives Q3. Q2 and Q3 are on when their gates are at ground, and off when their gates are at −15V. Thus Q3 turns on in NIGHT mode and connects jumper A into the circuit path, while Q2 turns on in DAY mode, and connects jumper B into the circuit path.

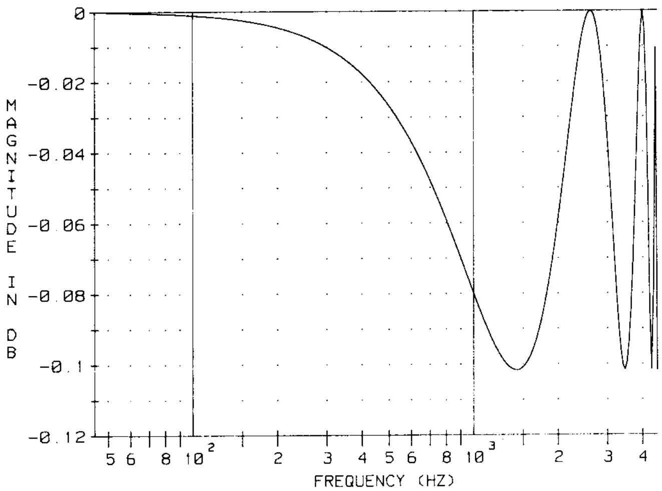

Fig. 6-15: Response of the First 4.5kHz Low-Pass Filter in the Passband
Card #1F4.5

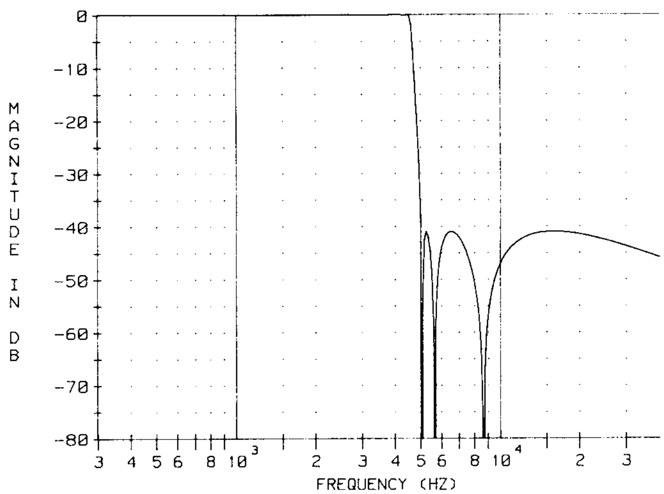

Fig. 6-16: Response of the First 4.5kHz Low-Pass Filter in the Passband and Stopband
Card #1F4.5

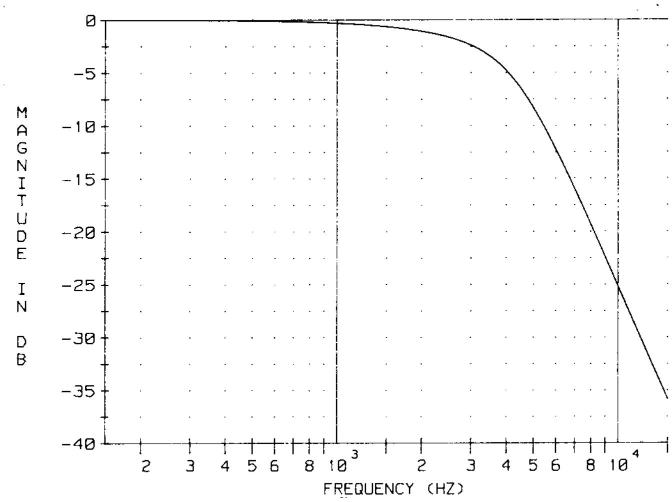

Fig. 6-17: Normal Frequency Response of that part of the Second 4.5kHz Filter associated with IC6b on Card #1F4.5

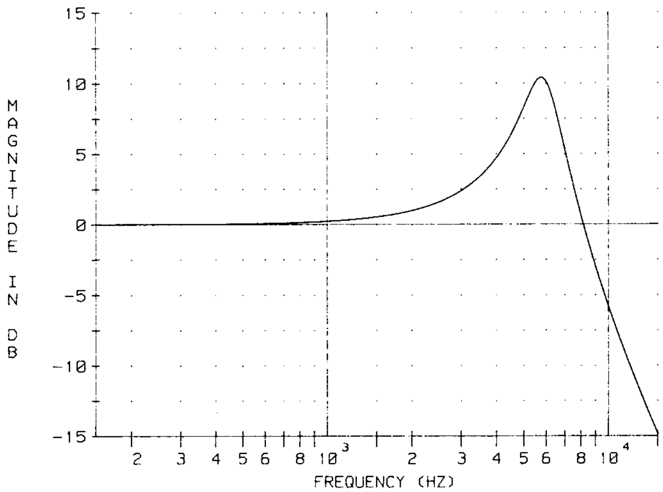

Fig. 6-18: Normal Frequency Response of that part of the Second 4.5kHz Filter associated with IC7a on Card #1F4.5

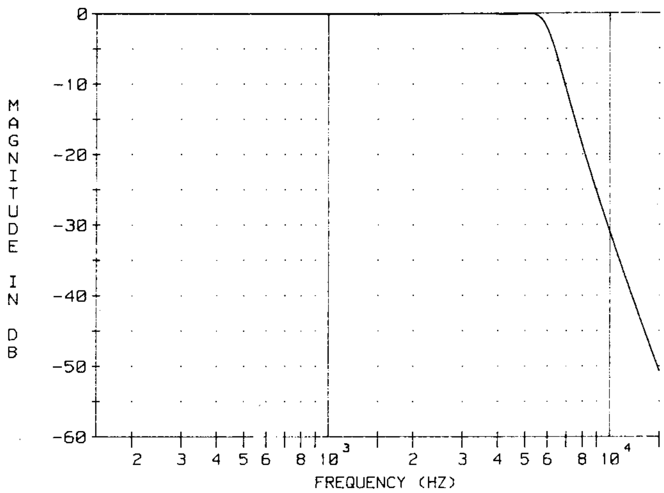

Fig. 6-19: Overall Frequency Response of the Second 4.5kHz Filter Card #1F4.5

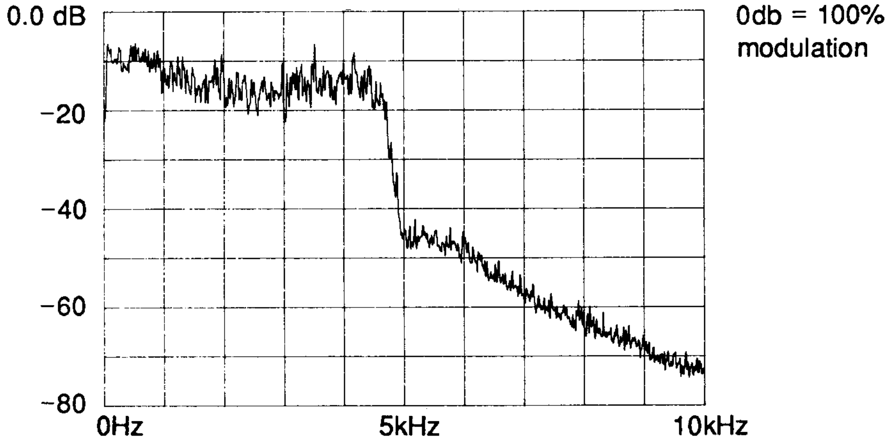

Fig. 6-20: Normal Output Power Spectrum of a Mono OPTIMOD-AM with 4.5kHz Filter Card #1F4.5

18. Safety Clipper

Located on Cards #7 and #10

The safety clipper provides final peak limiting. Realized with biased Schottky diodes, it is an extremely 'hard' clipper that produces substantially less intermodulation distortion than the 'soft' safety clippers often used in audio processing equipment. Further clipping (particularly soft clipping) should **not** be added to the system after OPTIMOD-AM output — it will cause the sound to become less defined and much more fatiguing. It will also introduce spurious high frequency spectral energy that may cause the occupied bandwidth regulations of the governing authorities to be exceeded.

The safety clipper in OPTIMOD-AM can be operated with as much as 100%/150% asymmetry. We recommend symmetrical operation for cleanest sound, especially for stereo operation (see page 1-10).

The safety clipper is buffered by an amplifier. In the L–R path only, the gain of this amplifier can be adjusted to match the L+R and L–R channel gains as closely as possible to maximize dynamic separation.

Component-level description:

Clipping is achieved with shunt clippers CR11, CR12, as buffered by IC5a. CR11, CR12 are biased by ±4.1V sources, realized by IC7 and associated circuitry. R75, R76 serve as a reference voltage divider of the +15V power supply. The voltage at the junction of R75 and R76 is equal to the clipping threshold, which is approximately ±4.5V peak.

Temperature compensation for the clipping diodes is supplied by CR14 and R77. The voltage at IC7a's (+) input varies according to the voltage drop across CR14, thereby achieving a constant threshold of clipping regardless of temperature variations in the turn-on voltage of CR11, CR12.

The −4.1V is created by 'amplifying' the +4.1V supply in unity-gain inverter IC7b, R78, R79. Asymmetry can be varied as desired by adjusting POS PEAK THRESH control R80. Additional current from R80 (through R81) is summed into IC7b to set the −4.1V supply between −4.1V and −6.4V. (Negative-going signals at this point in the circuit correspond to positive peaks).

The multi-band clippers are biased by IC8, which has circuitry topologically identical to the ±4.1 supply discussed immediately above.

To defeat clipping when the MODE switch is set to PROOF, both the ±4.1V and ±1.8V supplies are forced to approximately ±14V by CR13 and CR15. These diodes are connected to the proof bus, which floats when the MODE switch is set to OPERATE, and is connected to the +15V supply in when the MODE switch is set to PROOF.

19. Supersonic Low-pass Filter

Located on Cards #7 and #10

Almost all broad-band clipping in OPTIMOD-AM occurs on Card #1S10, #1F10, or #1F4.5 (depending on which is fitted in slot #1). The safety clipper is rarely active, but when it is, the sharp 'edges' caused by its clipping must be filtered to control occupied bandwidth. This filtering is accomplished with supersonic third-order non-overshooting low-pass filters located after each (L+R and L–R) safety clipper. This filter is down approximately 1dB at 10kHz and rolls off smoothly thereafter with an ultimate slope of 18dB/octave. It is realized as a unity-gain, positive feedback, single-amplifier, active filter.

Component-level description:

For further discussion of filter topology, see Wong and Ott's *Function Circuits* (McGraw-Hill, New York, 1976).

20. Transmitter Equalizer, Switching

Located on Cards #8 and #9

The transmitter equalizer is organized in three stages:

The first stage is an adjustable first-order all-pass network. If the transmitter/antenna system has non-constant group delay, this all-pass network can add delay as necessary to make the delay more constant, thereby improving the pulse response.

The second stage provides a 2.5dB shelving roll-off. The initial frequency of operation can be adjusted from approximately 500Hz to beyond OPTIMOD-AM's passband. This shelving roll-off will reduce or eliminate high-frequency ringing in the vast majority of antenna/transmitter systems that have high-frequency roll-off problems. The shelving roll-off is created differentially by subtracting the output of an adjustable high-pass filter from the main signal.

The third stage provides low-frequency tilt equalization in the L+R path (only) by creating a *positive slope* tilt in the output waveform to cancel the negative-slope tilt introduced by many plate-modulated transmitters. Control is provided over both the frequency at which the correction first begins to take effect (set by the LF BREAKPOINT controls), and the ultimate amount of low-frequency correction (set by the LF EQ controls).

A single TX EQ switch activates or defeats both the L+R and L–R channels.

Four sets of controls define four different transmitter equalization set-ups. Only one set of controls is active at any given time. Which set is active is determined by the momentary DAY/NIGHT and TX1/TX2 switches, or by remote control signals at the optically isolated TX1, TX2, DA (Day), and N (Night) terminals.

Component-level description:

High-frequency delay equalization is provided by first-order all-pass network IC2a and associated components, which subtract the output of a high-pass filter (formed by C1 and its load resistors R1, R2, R3, R4) from the main signal. The time constant (and thus the frequency at which the phase shift is 90°) is determined by the RC product of C1 and its loading resistors. One of four different time constants (for DAY/TX1, DAY/TX2, NIGHT/TX1, and NIGHT/TX2 operation) is selected by turning on switching FETs Q1, Q2, Q3, Q4 by applying 0V to their gates. The FETs are off when −15V is applied.

High-frequency shelving equalization is created through a similar subtraction, but only a fraction of the output of the high-pass filter is subtracted from its input.

Low-frequency tilt equalization is created inside a sealed, proprietary circuit module. The four sets of LF BREAKPOINT and LF EQ controls are switched by FETs on the auxiliary tilt equalization circuit board mounted on Card #8.

Two identical logic circuits work in concert to determine which of the four sets of transmitter equalization controls are active. Input to this logic is from the DAY/NIGHT and TX1/TX2 switches, the remote control terminals, or the power-up initialization circuit. The outputs of the two logic circuits form a 2-bit binary word which is decoded in binary decoder IC5a, with the result that only one of IC5a's output lines is at 0V (and therefore only one set of controls is active) at any one time.

Because the DAY/NIGHT and TX1/TX2 logic circuits are identical, only the DAY/NIGHT circuit will be detailed.

NAND gates IC4a and IC4b are cross-coupled to form a bistable multivibrator (flip-flop). This bistable changes state when the DAY/NIGHT switch is flipped or the transistor in one of the opto-isolators turns on and pulls its collector down to −15V. The DAY output of the bistable is the output of IC4b. IC1a is an inverting buffer, which buffers the DAY and NIGHT LED drive circuit.

Remote control pulses applied to the rear-panel terminals are routed through opto-isolators IC6 (DAY) and IC7 (NIGHT). Current-limiting and RF suppression are provided by resistors and feed-through capacitors within the filter box; rectification for AC control signals is provided by CR1.

Initialization circuit CR2, C11, R37 assures that the system always powers up in DAY mode. Upon power-up, the transition of the negative power supply from 0V to −15V is coupled through C11 and CR2 to IC4b. In steady-state conditions, R37 pulls the cathode of CR2 up to 0V. CR2 then effectively disconnects the power-up circuitry.

21. Sum-and-difference De-matrix

Stereo 9100B/2 units only. Located on Card #9.

The de-matrix transforms the L+R and L−R signals back into L/R format. It consists of an inverting summing amplifier and a differential amplifier. It can be mathematically demonstrated that this will result in correct decoding of the L+R and L−R

.

Ordinarily, the output of the de-matrix feeds the line amplifiers. By repositioning jumpers, the line amplifier can also be fed by L+R and L−R signals (or, one set of line amplifiers could be fed L/R while the other set was fed L+R/L−R).

Because de-matrixing inverts the absolute polarity of the signal, it will change the polarity of the signal corresponding to positive modulation. (This is only important if you are operating asymmetrically in stereo — which is not recommended because it introduces asymmetrical non-linear crosstalk between the left and right channels.) OPTIMOD-AM's output has been configured so that a positive-going signal at the OUT (+) terminal normally corresponds to positive modulation (in L+R/L−R or mono operation). When the de-matrix circuit is inserted (in L/R operation), a negative-going signal at the OUT (+) terminal corresponds to positive modulation.

Component-level description:

See the description of the electrically identical matrix circuit on page 6-16.

22. Balanced Line Amplifiers

Located on Cards #8 and #9

The line amplifiers are totally straightforward. They each consist of a pair of inverting opamps, which can drive 600 ohm loads directly.

The second opamp is a unity-gain inverter driven by the first opamp. The outputs of the two opamps thus provide an output balanced to ground which drives a non-overshooting EMI filter to interface to the outside world. The balanced driving capability of the circuit is approximately +20dBm into 600 ohms.

There are two balanced line amplifiers in the mono 9100B/1, and four in the stereo 9100B/2.

Component-level description:

Each output line amplifier consists of a non-inverting amplifier with a gain of 3 followed by an inverting amplifier with a gain of −1. Together these amplifiers provide a +26dBm balanced output capability, which is reduced to +20dBm by the following output pad and RF filter. Both amplifiers are 5532 opamps with high output current capacity.

Each amplifier is driven by its own 18-turn OUTPUT ATTEN control. AC coupling to eliminate accumulated offsets is provided by 47μF capacitors C3, C4, which are sufficiently large to avoid introducing any significant low-frequency tilt into highly processed waveforms.

The output amplifiers are isolated from the outside world by LC RFI filters, which are effective at both AM and FM frequencies. When properly loaded, these filters will not introduce ringing or overshoot.

23. Power Supplies

Mostly located on Card #PS

Most of the power for OPTIMOD-AM circuitry comes from a highly regulated ±15V power supply. The main supply is +15 volts, created by a 723C IC regulator with current-boosted output, current limiting, and over-voltage protection using a zener diode and fast-blow fuse.

The −15V supply is essentially a current-boosted opamp in a unity-gain inverting configuration which 'amplifies' and inverts the +15V supply, thus tracking it. The −15V supply is also current-limited and protected against overvoltage. Both +15V and −15V supplies are located on a circuit board mounted on the inside of the rear chassis apron. This apron is also used as a heat sink for the regulator power transistors.

Bias supplies are required for the diode clippers in the audio processing. There are two such supplies: the first creates approximately ±1.8 volts, while the second creates ±4.1 volts. The supplies are located on Card #7, and their outputs are used on both Card #7 and Card #10. Both supplies employ a pair of opamps: the first is a unity-gain voltage-follower with a temperature-compensated voltage input created by a resistor/diode network; the second is a unity-gain inverter which creates the complementary negative voltage. Asymmetrical modulation can be achieved by summing additional current into the inverter (thus creating an asymmetrical bias on the clipper diodes) through the POS PEAK THRESH control.

The CLIPPING control adjusts a similar supply on Card #6 (range = ±0.5V to ±1.0V). This supply provides a reference for all of the comparators in the six-band limiter, and thus determines the threshold of limiting for the six-band limiter.

Component-level description:

The unregulated power supply (mounted inside the chassis, but outside of the RF-tight enclosure) is wholly conventional. It consists of dual-primary transformer T101, two full-wave rectifiers (CR101, CR102 and CR103, CR104), and two energy storage capacitors (C101 and C102).

T101's primary can be configured for 115 volt operation by paralleling its two primaries, or for 230 volt operation by connecting its two primaries in series (with a switch). RF filtering is provided on the AC line by FL101. In addition, C103, C104, C105, C106, C107, L101, L102 filter RF from the unregulated DC supply lines as they enter the chassis. The chassis is divided into three major sections to facilitate RF suppression. The section to the left (unregulated power supply chamber) contains the AC wiring and the unregulated power supply, and is assumed to contain some RF. The card cage, to the right, uses RF suppression on each line entering or leaving the area, and is thus free from RF. The RF shielding box on the rear panel, which interfaces the audio input and output lines with the outside world, contains the input pads — its connections to the main RF-tight compartment are all RF-filtered.

The +15 volt regulator (located on Card #PS) is the main reference for all other voltages in OPTIMOD-AM. It employs 723C IC voltage regulator IC101 in conjunction with external series-pass transistor Q101. This transistor is mounted on the rear apron of the chassis, which serves as a heat sink.

IC101 contains a reference voltage source, an opamp (externally compensated by C109 to prevent oscillation), and a current-limiting transistor. The reference voltage (nominally +7.15V) is developed at pin 6. C108 filters high-frequency noise from the reference voltage, which is directly connected to the non-inverting input (pin 5) of the internal opamp. Voltage divider R105, R106, R107 develops a precise fraction of the output voltage of the regulator at the wiper of +15V ADJUST trimmer R106. The wiper of R106 is connected to the inverting input of IC101's internal opamp. Negative feedback forces the voltage at R106's wiper to be equal to the reference voltage, so the output voltage of the regulator is always the reference voltage divided by the voltage divider gain.

The output current flowing through Q101 develops a voltage drop across R103. When the current exceeds approximately ¾-amp, the voltage drop is sufficient to turn on the current-limiting transistor inside IC101. Since this transistor's base-emitter junction is connected to pins 2 and 3 of IC101, it then shunts base drive current from the external series-pass transistor Q101 and prevents damage due to overheating.

If a catastrophic failure in the +15 volt regulator causes it to lose control over its output voltage, the rest of the circuitry must be protected against the full unregulated voltage, or the entire system will be severely damaged. This protection is provided by zener diode VR101, CR105, and 1-amp fast-blow fuse F102. If the regulator loses control of the output voltage, VR101 will conduct and limit the output voltage to approximately 16.5 volts (which will not damage the system). Extremely large amounts of current will flow in VR101. Ordinarily, this current will blow F102 and disconnect the circuitry from the unregulated supply before VR101 is damaged. VR101's clamping action will also prevent the negative tracking supply from exceeding −16.5 volts. When the regulator is operating properly, the current-limiting circuitry will prevent F102 from blowing even if the regulator output is short-circuited. (In certain unusual circumstances, the current-limiting circuit may still work, even though the regulator has lost control of its output voltage. If this occurs, F102 will not blow, and VR101 will overheat and burn out. Because its failure mode is a short-circuit, VR101 will still protect OPTIMOD-AM circuitry even in this exceptional circumstance.)

The −15 volt regulator (located on Card #PS) is an opamp that contains a discrete power-booster output stage with current-limiting. It 'amplifies' the output of the +15 volt regulator by −1 to produce a −15 volt tracking supply. Shutdown of the +15 volt supply (due to current-limiting conditions or to a fault which blows F102) will also result in shutdown of the −15 volt supply. The basic opamp is IC102. Its input resistor R109 and feedback resistor R108 are of equal value, resulting in a gain of −1 ±2%. IC102's negative supply comes from the *unregulated* −22-volt supply. The common-mode range of IC102 includes its positive power supply, which permits operation with the chip's positive supply at ground. In normal operating conditions, the (+) input of IC102 is grounded, and its (−) input is within 10mV of ground.

Q103 and Q102 form a conjugate emitter-follower which can boost the output current of IC102 to more than 3/4-amp. The basic emitter-follower is Q103. Q102 is connected in a 100% negative feedback configuration to boost the current output capability of Q103.

Q104 is a current-limiting transistor. If the −15 volt supply is called upon to deliver more than 3/4-amp, a sufficient voltage drop (approximately 0.6 volts) will occur across R104 to turn on Q104, thus shunting drive current away from Q103 into the load and protecting Q102 and Q103 from burn-out (IC102 is protected by internal current-limiting circuitry). C113 frequency-compensates the −15 volt supply to protect it against high-frequency oscillations. R102 increases the circuit's immunity to leakage in Q103.

Zener clamp VR102, CR106, and fuse F103 protect the rest of the circuitry from a catastrophic failure of the −15 volt regulator. The operation of this circuit is identical to the operation of the corresponding circuit in the +15 volt regulator.

Parts List

Because special or subtle characteristics of certain components have been exploited to produce an elegant design at a reasonable cost, *it is unwise to make substitutions for listed parts.* Consult with Orban Customer Service (see page 5-18) if the parts list indicates that a part is specially selected, or that realignment is required when the part is replaced.

Orban maintains an inventory of tested, exact replacement parts that can be supplied quickly at nominal cost. Spare parts kits are also available. When ordering parts from Orban, please be ready to supply the following information:

Orban part number
Reference designator (e.g., C3, R78, IC14)
Description of part
Model, serial, and M number of unit — see rear-panel label
(not all units have M numbers)

Parts are listed by card or assembly (except for widely used common parts, which are described below), and the parts on each card are grouped by type. See the assembly drawings for locations of components.

To facilitate future maintenance, we have used components from well-established manufacturers with worldwide distribution whenever possible. The abbreviations used for manufacturers are listed on page 6-59, along with their USA headquarters addresses.

Widely used common parts:

Diodes: Unless specified by reference designator in the following, all signal diodes are 1N4148 (Orban part number 22101-000). This is a silicon, small-signal diode with ultra-fast recovery and high conductance. It may also be replaced with 1N914 (BAY-61 in Europe). (BV: 75V min. @ I_r = 5μA, I_r: 25nA max. @ V_r = 20V, V_f: 1.0V max. @ I_f = 100mA t_{rr}: 4ns max.)

Resistors: Resistors should only be replaced with the same style and with the *exact* value marked on the resistor body. If the value marking is not legible, check the schematic or contact Orban Customer Service (see page 5-18). Performance and stability will be compromised if you do not use exact replacements.

Unless specified by reference designator in the following, the resistors in this unit are:

Metal film resistors with conformally-coated bodies, value identified with five color bands or printed on body; rated 1/8-watt @ 70°C, with a ±1% tolerance, and with a temperature coefficient of 100 PPM/°C; Orban part numbers 20038-xxx through 20045-xxx, USA Military Specification MIL-R-10509 style RN55D, manufactured by R-Ohm (CRB-1/4FX), TRW/IRC, Beyschlag, Dale, Corning, Matsushita,

Carbon film resistors with conformally-coated bodies, value identified with four color bands; rated 1/4-watt @ 70°C, with a tolerance of ±5%; Orban part numbers 20001-xxx, manufactured by R-Ohm (R-25), Piher, Beyschlag, Dale, Phillips, Spectrol, Matsushita,

Carbon composition resistors with molded phenolic bodies, value identified with four color bands; rated 1/4-watt for the 0.09 × 0.25-inch (2.3 × 6.4mm) size, and rated 1/2 watt for the 0.14 × 0.375-inch (3.6 × 9.5mm) size @ 70° C, with a tolerance of ±5%; Orban part numbers 2001x-xxx, USA Military Specification MIL-R-11 style RC-07 or RC-20, manufactured by Allen-Bradley, TRW/IRC, Matsushita,

Cermet trimmer resistors with 3/8-inch (9mm) square bodies, value printed on side; rated 1/2-watt @ 70°C, with a tolerance of ±10%, and a temperature coefficient of 100 PPM/°C; Orban part numbers 20510-xxx and 20511-xxx, manufactured by Beckman (72P, 68W-series), Spectrol, Matsushita.

10kHz FILTER CARD (ON CARD #1S10)

Capacitors

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS (1)	NOTES
C1-8	Polypropylene, 50V, 1%; 4700pF	21701-247	NOB	CQ15P1H472FPP	WES	
C9,10	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C11,12	Polypropylene, 50V, 1%; 4700pF	21701-247	NOB	CQ15P1H472FPP	WES	
C13	Mica, 500V, 1%; 680pF	21022-168	CD	CD19-FD681F03	SAN	
C14	Polypropylene, 50V, 1%; 0.01uF	21701-310	NOB	CQ15P1H103FPP	WES	
C15	Mica, 500V, 1%; 220pF	21018-122	CD	CD15-FD221F03	SAN	
C16,17	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C18-25	Polypropylene, 50V, 1%; 4700pF	21701-247	NOB	CQ15P1H472FPP	WES	
C26,27	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C28,29	Polypropylene, 50V, 1%; 4700pF	21701-247	NOB	CQ15P1H472FPP	WES	
C30	Mica, 500V, 1%; 680pF	21022-168	CD	CD19-FD681F03	SAN	
C31	Polypropylene, 50V, 1%; 0.01uF	21701-310	NOB	CQ15P1H103FPP	WES	
C32	Mica, 500V, 1%; 220pF	21018-122	CD	CD15-FD221F03	SAN	
C33,34	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C35-42	Monolythic Ceramic, 50V, 20%; 0.1uF	21123-410	SPR	1C25 Z5U104M050B	KEM	
C43,44	Polypropylene, 50V, 1%; 0.01uF	21701-310	NOB	CQ15P1H103FPP	WES	

Diodes

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS (1)	NOTES
CR1-8	Diode, Signal, Hot Carrier	22102-001	HP	HP5082-2800		

Integrated Circuits

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS (1)	NOTES
IC1-5	Linear, Dual Opamp	24206-202	TI	TL072CP	MOT	
IC6,7	Linear, Dual Opamp	24207-202	SIG	NE5532N	TI,EXR	
IC8-12	Linear, Dual Opamp	24206-202	TI	TL072CP	MOT	
IC13,14	Linear, Dual Opamp	24207-202	SIG	NE5532N	TI,EXR	
IC15	Linear, Dual Opamp	24209-202	NAT	LF412CN		

Resistors

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS (1)	NOTES
R7	Resistor Set, MF, 2.00K	28520-002	ORB			3
R11	Resistor Set, MF, 2.00K	28520-002	ORB			3
R15	Resistor Set, MF, 2.00K	28520-002	ORB			3
R22	Resistor Set, MF, 20.0K	28521-001	ORB			3
R37	Resistor Set, MF, 20.0K	28521-001	ORB			3
R48	Resistor Set, MF, 2.00K	28520-002	ORB			3
R52	Resistor Set, MF, 2.00K	28520-002	ORB			3
R56	Resistor Set, MF, 2.00K	28520-002	ORB			3
R63	Resistor Set, MF, 20.0K	28521-001	ORB			3
R78	Resistor Set, MF, 20.0K	28521-001	ORB			3

FOOTNOTES:

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

SPECIFICATIONS AND SOURCES FOR REPLACEMENT PARTS

OPTIMOD-AM 9100B

10kHz Filter Card-Capacitors, Diodes, Integrated Circuits, Resistors

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS (1)	NOTES
CARD #1F10 (9100B/1)						
Capacitors						
C1	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C2	Mica, 500V, 1%; 150pF	21018-115	CD	CD15-FD151F03	SAN	
C3-5	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C6	Polypropylene, 50V, 1%; 0.01uF	21701-310	NOB	CQ15P1H103FPP	WES	
C7	Mica, 500V, 1%; 100pF	21018-110	CD	CD15-FD101F03	SAN	
C8-15	Polypropylene, 50V, 1%; 4700pF	21701-247	NOB	CQ15P1H472FPP	WES	
C16,17	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C18,19	Polypropylene, 50V, 1%; 4700pF	21701-247	NOB	CQ15P1H472FPP	WES	
C20	Mica, 500V, 1%; 680pF	21022-168	CD	CD19-FD681F03	SAN	
C21	Polypropylene, 50V, 1%; 0.01uF	21701-310	NOB	CQ15P1H103FPP	WES	
C22	Mica, 500V, 1%; 220pF	21018-122	CD	CD15-FD221F03	SAN	
C23,24	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C25,26	Alum., Radial, 25V; 100uF	21206-710	PAN	ECE-A1EV101S	MANY	
C27-31	Monolythic Ceramic, 50V, 20%; 0.1uF	21123-410	SPR	1C25 Z5U104M050B	KEM	
C32	Polypropylene, 50V, 1%; 0.01uF	21701-310	NOB	CQ15P1H103FPP	WES	
C33,34	Monolythic Ceramic, 50V, 20%; 0.1uF	21123-410	SPR	1C25 Z5U104M050B	KEM	
Diodes						
CR1-4	Diode, Signal, Hot Carrier	22102-001	HP	HP5082-2800		
Integrated Circuits						
IC1-5	Linear, Dual Opamp	24206-202	TI	TL072CP	MOT	
IC6-9	Linear, Dual Opamp	24207-202	SIG	NE5532N	TI,EXR	
IC10	Linear, Dual Opamp	24209-202	NAT	LF412CN		
Resistors						
R28	Resistor Set, MF, 2.00K	28520-002	ORB			3
R32	Resistor Set, MF, 2.00K	28520-002	ORB			3
R37	Resistor Set, MF, 2.00K	28520-002	ORB			3
R43	Resistor Set, MF, 20.0K	28521-001	ORB			3
R58	Resistor Set, MF, 20.0K	28521-001	ORB			3
Transistors						
Q1	Transistor, Signal, NPN	23202-101	MOT	2N4400	FSC	
Q2,3	Transistor, JFET/N	23406-101	NAT	J113	SIL	

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

SPECIFICATIONS AND SOURCES FOR REPLACEMENT PARTS

OPTIMOD-AM 9100B

Card #1F10--Capacitors, Diodes, Integrated Circuits, Resistors, Transistors

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS (1)	NOTES
CARD #1F4.5, 1F5.0, 1F6.0 (RET-052)						
Capacitors						
C1	Mica, 500V, 1%; 100pF	21018-110	CD	CD15-FD101F03	SAN	
C2-10	Polypropylene, 50V, 1%; 0.01uF	21701-310	NOB	CQ15P1H103FPP	WES	
C11,12	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C13	Polypropylene, 50V, 1%; 4700pF	21701-247	NOB	CQ15P1H472FPP	WES	
C14	Mica, 500V, 1%; 680pF	21022-168	CD	CD19-FD681F03	SAN	
C15	Polypropylene, 50V, 1%; 4700pF	21701-247	NOB	CQ15P1H472FPP	WES	
C16	Polypropylene, 50V, 1%; 0.01uF	21701-310	NOB	CQ15P1H103FPP	WES	
C17	Mica, 500V, 1%; 220pF	21018-122	CD	CD15-FD221F03	SAN	
C18,19	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C20,21	Alum., Radial, 25V; 100uF	21206-710	PAN	ECE-A1EV101S	MANY	
C22-28	Monolythic Ceramic, 50V, 20%; 0.1uF	21123-410	SPR	1C25 Z5U104M050B	KEM	
Diodes						
CR1-4	Diode, Signal, Hot Carrier	22102-001	HP	HP5082-2800	MANY	
Integrated Circuits						
IC1-5	Linear, Dual Opamp	24206-202	TI	TL072CP	MOT	
IC6-8	Linear, Dual Opamp	24207-202	SIG	NE5532N	TI,EXR	
IC9	Linear, Dual Opamp	24209-202	NAT	LF412CN		
Resistors						
R19	Resistor Set, MF; 2.00K	28520-002	ORB			3
R23	Resistor Set, MF; 2.00K	28520-002	ORB			3
R27	Resistor Set, MF; 2.00K	28520-002	ORB			3
R34	Resistor Set, MF; 20.0K	28521-001	ORB			3
R49	Resistor Set, MF; 20.0K	28521-001	ORB			3
Transistors						
Q1,2	Transistor, JFET/N	23406-101	NAT	J113	SIL	
Q3	Transistor, Signal, NPN	23202-101	MOT	2N4400	FSC	

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

SPECIFICATIONS AND SOURCES FOR REPLACEMENT PARTS

OPTIMOD-AM 9100B

Card #1F4.5, 1F5.0, 1F6.0—Capacitors, Diodes, Integrated Circuits, Resistors, Transistors

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS(1)	NOTES
CARD #1S10 (9100B/2)						
Capacitors						
C1	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C2	Mica, 500V, 1%; 150pF	21018-115	CD	CD15-FD151F03	SAN	
C3-5	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C6	Polypropylene, 50V, 1%; 0.01uF	21701-310	NOB	CQ15P1H103FPP	WES	
C7	Mica, 500V, 1%; 100pF	21018-110	CD	CD15-FD101F03	SAN	
C8-10	Polypropylene, 50V, 1%; 0.01uF	21701-310	NOB	CQ15P1H103FPP	WES	
C11	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C12	Mica, 500V, 1%; 150pF	21018-115	CD	CD15-FD151F03	SAN	
C13-15	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C16	Polypropylene, 50V, 1%; 0.01uF	21701-310	NOB	CQ15P1H103FPP	WES	
C17	Mica, 500V, 1%; 100pF	21018-110	CD	CD15-FD101F03	SAN	
C18-22	Polypropylene, 50V, 1%; 0.01uF	21701-310	NOB	CQ15P1H103FPP	WES	
C23	Tantalum, 35V, 10%; 0.22uF	21307-422	SPR	196D 224X9035HA1	MANY	
C24	Met. Polyester, 100V, 5%; 0.047uF	21440-347	WES	60C 473J250	SIE,WIM	
C25	Mica, 500V, 5%; 470pF	21024-147	CD	CD19-FD471J03	SAN	
C26	Polypropylene, 50V, 1%; 0.01uF	21701-310	NOB	CQ15P1H103FPP	WES	
C27	Alum., Radial, 25V; 100uF	21206-710	PAN	ECE-A1EV101S	MANY	
C28,29	Monolythic Ceramic, 50V, 20%; 0.1uF	21123-410	SPR	1C25 Z5U104M050B	KEM	
C30	Alum., Radial, 25V; 100uF	21206-710	PAN	ECE-A1EV101S	MANY	
C31,32	Monolythic Ceramic, 50V, 20%; 0.1uF	21123-410	SPR	1C25 Z5U104M050B	KEM	
Diodes						
CR1,2	Diode, Signal, Hot Carrier	22102-001	HP	HP5082-2800		
CR6,7	Diode, Signal, Hot Carrier	22102-001	HP	HP5082-2800		
CR11-13	Diode, Signal, Hot Carrier	22102-001	HP	HP5082-2800		
Integrated Circuits						
IC1-3	Linear, Dual Opamp	24206-202	TI	TL072CP	MOT	
IC4	Linear, Dual Opamp	24202-202	RAY	RC4558NB	MOT,FSC	
IC5	Linear, Dual Opamp	24206-202	TI	TL072CP	MOT	
IC6	Linear, Single Opamp	24003-202	RCA	CA301CN	NAT,TI	
IC7	Linear, Single Opamp	24014-202	SIG	NE5534N	TI	
IC8	Linear, Dual Opamp	24206-202	TI	TL072CP	MOT	
IC9	Linear, Single Opamp	24003-202	RCA	CA301CN	NAT,TI	
IC10	Linear, Dual Opamp	24209-202	NAT	LF412CN		
IC11	Linear, Dual Opamp	24206-202	TI	TL072CP	MOT	
IC12	Not Used	---				
IC13,14	Linear, Dual Opamp	24206-202	TI	TL072CP	MOT	

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

SPECIFICATIONS AND SOURCES FOR REPLACEMENT PARTS

OPTIMOD-AM 9100B

Card #1S10—Capacitors, Diodes, Integrated Circuits

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS (1)	NOTES
Resistors						
R4	Resistor Set, MF, 20.5K	28521-008	ORB			3
R8	Resistor Set, MF, 20.5K	28521-008	ORB			3
R18	Resistor Set, MF, 20.5K	28521-008	ORB			3
R25	Resistor Set, MF, 20.5K	28521-008	ORB			3
R29	Resistor Set, MF, 20.5K	28521-008	ORB			3
R85	Trimpot, Cermet, 1 Turn; 100 OHM	20520-110	BEK	82PA100	BRN	
R87,88	Resistor Set, MF, 20.5K	28521-008	ORB			3
Transistors						
Q1-4	Transistor, JFET/N	23406-101	NAT	J113	SIL	
Q5	Transistor, JFET/N	23403-101	NAT	J111	INS	
Q6	Transistor, Signal, NPN	23202-101	MOT	2N4400	FSC	
Card #2 and Card #3						
Capacitors						
C1	Mica, 500V, 5%; 150pF	21020-115	CD	CD15-FD151J03	SAN	
C2	Mica, 500V, +1/2pF -1/2pF; 5pF	21017-005	CD	CD15-CD050D03	SAN	
C3	Met. Polyester, 100V, 10%; 0.1uF	21441-410	WIM	MKS-4100V5.0.1	WES,SIE	
C4	Mica, 500V, 1%; 100pF	21018-110	CD	CD15-FD101F03	SAN	
C5	Mica, 500V, +1/2pF -1/2pF; 10pF	21017-010	CD	CD15-CD100D03	SAN	
C6	Mica, 500V, 5%; 150pF	21020-115	CD	CD15-FD151J03	SAN	
C7	Mica, 500V, +1/2pF -1/2pF; 5pF	21017-005	CD	CD15-CD050D03	SAN	
C8	Met. Polyester, 100V, 10%; 0.1uF	21441-410	WIM	MKS-4100V5.0.1	WES,SIE	
C9	Mica, 500V, 1%; 100pF	21018-110	CD	CD15-FD101F03	SAN	
C10	Met. Polyester, 100V, 10%; 0.1uF	21441-410	WIM	MKS-4100V5.0.1	WES,SIE	
C11,12	Mica, 500V, +1/2pF -1/2pF; 10pF	21017-010	CD	CD15-CD100D03	SAN	
C13	Met. Polyester, 100V, 10%; 0.1uF	21441-410	WIM	MKS-4100V5.0.1	WES,SIE	
C14	Mica, 500V, +1/2pF -1/2pF; 10pF	21017-010	CD	CD15-CD100D03	SAN	
C15	Met. Polyester, 100V, 10%; 0.1uF	21441-410	WIM	MKS-4100V5.0.1	WES,SIE	
C16,17	Mica, 500V, +1/2pF -1/2pF; 10pF	21017-010	CD	CD15-CD100D03	SAN	
C18	Met. Polyester, 100V, 10%; 0.1uF	21441-410	WIM	MKS-4100V5.0.1	WES,SIE	
C19	Mica, 500V, +1/2pF -1/2pF; 10pF	21017-010	CD	CD15-CD100D03	SAN	
C20	Met. Polyester, 100V, 10%; 0.1uF	21441-410	WIM	MKS-4100V5.0.1	WES,SIE	
C21,22	Mica, 500V, +1/2pF -1/2pF; 10pF	21017-010	CD	CD15-CD100D03	SAN	
C23	Met. Polyester, 100V, 10%; 0.1uF	21441-410	WIM	MKS-4100V5.0.1	WES,SIE	
C24	Mica, 500V, +1/2pF -1/2pF; 10pF	21017-010	CD	CD15-CD100D03	SAN	
C25	Polyester, 100V, 10%; 0.0022uF	21401-222	SPR	225P 22291WD3	PAN,PAK	
C26,27	Monolythic Ceramic, 50V, 20%; 0.1uF	21123-410	SPR	1C25 Z5U104M050B	KEM	
C28	Alum., Radial, 25V; 100uF	21206-710	PAN	ECE-A1EV101S	MANY	
C29,30	Monolythic Ceramic, 50V, 20%; 0.1uF	21123-410	SPR	1C25 Z5U104M050B	KEM	
C31	Alum., Radial, 25V; 100uF	21206-710	PAN	ECE-A1EV101S	MANY	
C32,33	Mica, 500V, +1/2pF -1/2pF; 5pF	21017-005	CD	CD15-CD050D03	SAN	

FOOTNOTES:
(1) See last page for abbreviations
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(3) Actual part is specially selected from part listed, consult Factory
(4) Realignment may be required if replaced, see Circuit Description and/or Alignment Instructions

SPECIFICATIONS AND SOURCES FOR REPLACEMENT PARTS

OPTIMOD-AM 9100B

Card #1S10–Resistors, Transistors
Card #2 and Card #3–Integrated Circuits, Resistors, Transistors

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS (1)	NOTES
Card #2 and Card #3 (continued)						
Integrated Circuits						
IC1	Linear, Dual Opamp	24206-202	TI	TL072CP	MOT	
IC2	Linear, Dual Opamp	24208-303	ORB	CA3280AG Selected		
IC3	Linear, Dual Opamp	24206-202	TI	TL072CP	MOT	
IC4	Linear, Dual Opamp	24208-303	ORB	CA3280AG Selected		
IC5	Linear, Dual Opamp	24209-202	NAT	LF412CN		
IC6	Linear, Dual Opamp	24206-202	TI	TL072CP	MOT	
IC7	Linear, Dual Opamp	24208-303	ORB	CA3280AG Selected		
IC8	Linear, Dual Opamp	24206-202	TI	TL072CP	MOT	
IC9	Linear, Dual Opamp	24208-303	ORB	CA3280AG Selected		
IC10	Linear, Dual Opamp	24209-202	NAT	LF412CN		
IC11	Multiple FET	24402-302	NAT	LM3046N	RCA	
IC12	Linear, Dual Opamp	24207-202	SIG	NE5532N	TI,EXR	
IC13	Linear, Dual Opamp	24208-303	ORB	CA3280AG Selected		
IC14	Linear, Dual Opamp	24207-202	SIG	NE5532N	TI,EXR	
IC15	Linear, Dual Opamp	24208-303	ORB	CA3280AG Selected		
IC16	Linear, Dual Opamp	24206-202	TI	TL072CP	MOT	
IC17	Linear, Single Opamp	24014-202	SIG	NE5534N	TI	
IC18	Linear, Dual Opamp	24208-303	ORB	CA3280AG Selected		
IC19	Linear, Single Opamp	24014-202	SIG	NE5534N	TI	
IC20	Linear, Dual Opamp	24208-303	ORB	CA3280AG Selected		
IC21	Linear, Dual Opamp	24209-202	NAT	LF412CN		
Resistors						
R4a-d	Trimpot, Cermet, 1 Turn; 100K	20524-410	BRN	3329H-1-104		
R32a-d	Trimpot, Cermet, 1 Turn; 100K	20524-410	BRN	3329H-1-104		
R61a-d	Trimpot, Cermet, 1 Turn; 100K	20524-410	BRN	3329H-1-104		
R89a-d	Trimpot, Cermet, 1 Turn; 100K	20524-410	BRN	3329H-1-104		
Transistors						
Q1-4	Transistor, Signal, PNP	23002-101	MOT	2N4402	FSC	

FOOTNOTES:
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(2) No Alternate Vendors known at publication
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SPECIFICATIONS AND SOURCES FOR REPLACEMENT PARTS

OPTIMOD-AM 9100B

Card #2 and Card #3—Integrated Circuits, Resistors, Transistors

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

Card #4 and Card #5

Capacitors

C1	Mica, 500V, 1%; 270pF	21018-127	CD	CD15-FD271F03	SAN	
C2	Mica, 500V, 1%; 560pF	21022-156	CD	CD19-FD561F03	SAN	
C3	Mica, 500V, 1%; 270pF	21018-127	CD	CD15-FD271F03	SAN	
C4	Met. Polycarb., 100V, 1%; 0.01uF	21601-310	ECI	652A 1B103F	IMB,SO	
C5-9	Polypropylene, 50V, 2.5%; 0.01uF	21702-310	NOB	CQ15P1H103GPP	WES	
C10	Met. Polyester, 100V, 5%; 0.47uF	21440-447	WES	60F 474J100	SIE,WIM	
C11,12	Met. Polyester, 100V, 5%; 0.1uF	21440-410	WES	60C 104J100	SIE,WIM	
C13	Polypropylene, 50V, 1%; 0.01uF	21701-310	NOB	CQ15P1H103FPP	WES	
C14-16	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C17,18	Polypropylene, 50V, 2.5%; 0.01uF	21702-310	NOB	CQ15P1H103GPP	WES	
C19	Met. Polycarb., 100V, 1%; 0.1uF	21601-410	ECI	652A 1B104F	IMB,SO	
C20	Alum., Radial, 63V; 33uF	21209-633	SPR	502D 336G063CC1C	PAN	
C21-32	Polypropylene, 50V, 2.5%; 0.01uF	21702-310	NOB	CQ15P1H103GPP	WES	
C33-38	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C39,40	Alum., Radial, 25V; 100uF	21206-710	PAN	ECE-A1EV101S	MANY	
C41-46	Monolythic Ceramic, 50V, 20%; 0.1uF	21123-410	SPR	1C25 Z5U104M050B	KEM	

Integrated Circuits

IC1-3	Linear, Dual Opamp	24206-202	TI	TL072CP	MOT	
IC4	Linear, Single Opamp	24013-202	TI	TL071CP		
IC5-8	Linear, Dual Opamp	24206-202	TI	TL072CP	MOT	
IC9	Linear, Dual Opamp	24202-202	RAY	RC4558NB	MOT,FSC	
IC10-13	Linear, Dual Opamp	24206-202	TI	TL072CP	MOT	
IC14	Linear, Dual Opamp	24207-202	SIG	NE5532N	TI,EXR	

Modules

R96	Module, Sub-Assy, Equalizer, Blue	40045-000	ORB			3

Resistors

R7	Pot, Single; 25K (5010R)	20742-000	ORB			10% CCW Log
R22,23	Resistor Set, MF; 20.5K	28521-008	ORB			3
R35	Pot, Single, 10K, (5050)	20720-000	ORB			Linear
R36	Pot, Single, 50K, (5020R)	20724-000	ORB			20% CCW Log
R43	Pot, Single, 10K, (5050)	20720-000	ORB			Linear
R46	Pot, Single, 500K, (5010R)	20746-000	ORB			10% CCW Log
R49	Pot, Single, 100K, (5020)	20726-000	ORB			20% CW Log

Switches

S1	Switch, Toggle, Min.; SPDT	26041-102	CK	7101SYABE		

FOOTNOTES:
(1) See last page for abbreviations
(2) No Alternate Vendors known at publication
(3) Actual part is specially selected from part listed, consult Factory
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SPECIFICATIONS AND SOURCES FOR REPLACEMENT PARTS

OPTIMOD-AM 9100B

Card #4 and Card #5—Capacitors, Integrated Circuits, Modules, Resistors, Switches

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS (1)	NOTES
CARD #6						
Capacitors						
C1-6	Monolythic Ceramic, 50V, 20%; 0.1uF	21123-410	SPR	1C25 Z5U104M050B	KEM	
C7	Tantalum, 35V, 10%; 2.2uF	21307-522	SPR	196D 225X9035JA1	MANY	
C8	Ceramic Disc, 1KV, 10%; 0.001uF	21112-210	CRL	DD-102	MUR	
C9	Tantalum, 35V, 10%; 1uF	21307-510	SPR	196D 105X9035HA1	MANY	
C10-12	Met. Polyester, 100V, 10%; 0.1uF	21441-410	WIM	MKS-4100V5.0.1	WES,SIE	
C13-15	Alum., Radial, 25V; 100uF	21206-710	PAN	ECE-A1EV101S	MANY	
C16-19	Monolythic Ceramic, 50V, 20%; 0.1uF	21123-410	SPR	1C25 Z5U104M050B	KEM	
C20,21	Alum., Radial, 25V; 100uF	21206-710	PAN	ECE-A1EV101S	MANY	
Diodes						
CR11	Diode, Zener, 1W; 9.1V	22003-091	MOT	1N4739		
Integrated Circuits						
IC1,2	Dual Comparator	24701-302	NAT	LM711CN	RAY,TI	
IC3,4	Linear, Dual Opamp	24209-202	NAT	LF412CN		
IC5,6	Dual Comparator	24701-302	NAT	LM711CN	RAY,TI	
IC7	Linear, Dual Opamp	24209-202	NAT	LF412CN		
IC8	Linear, Dual Opamp	24202-202	RAY	RC4558NB	MOT,FSC	
IC9,10	Dual Comparator	24701-302	NAT	LM711CN	RAY,TI	
IC11	Linear, Dual Opamp	24209-202	NAT	LF412CN		
IC12	Linear, Dual Opamp	24202-202	RAY	RC4558NB	MOT,FSC	
Modules						
A1-3	Module Assy, Release Time	30665-001-xx*	ORB			*Add suffix printed on part
A4	Module Assy, Timing	30670-000-xx*	ORB			*Add suffix printed on part
Resistors						
R44	Pot, Single, 100K, (5020R)	20736-000	ORB			20% CCW Log
R65	Pot, Single, 10K, (5050)	20720-000	ORB			Linear
Switches						
S1	Switch, Toggle, Min.; DPDT	26041-202	CK	7201SYABE		
S2	Switch, Toggle, Min.; SPDT	26041-102	CK	7101SYABE		

FOOTNOTES:
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SPECIFICATIONS AND SOURCES FOR REPLACEMENT PARTS

OPTIMOD-AM 9100B

Card #6—Capacitors, Diodes, Integrated Circuits, Modules, Resistors, Switches

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS (1)	NOTES
Card #6 (continued)						
Transistors						
Q1	Transistor, Signal, NPN	23202-101	MOT	2N4400	FSC	
Q2	Transistor, Signal, PNP	23002-101	MOT	2N4402	FSC	
Q3	Transistor, Signal, NPN	23202-101	MOT	2N4400	FSC	
Q4	Transistor, Signal, PNP	23002-101	MOT	2N4402	FSC	
Q5	Transistor, Signal, NPN	23202-101	MOT	2N4400	FSC	
Q6	Transistor, Signal, PNP	23002-101	MOT	2N4402	FSC	
Q7	Transistor, Signal, NPN	23202-101	MOT	2N4400	FSC	
Q8	Transistor, Signal, PNP	23002-101	MOT	2N4402	FSC	
Q9	Transistor, Signal, NPN	23202-101	MOT	2N4400	FSC	
Q10	Transistor, Signal, PNP	23002-101	MOT	2N4402	FSC	
Q11	Transistor, Signal, NPN	23202-101	MOT	2N4400	FSC	
Q12	Transistor, Signal, PNP	23002-101	MOT	2N4402	FSC	
Q13	Transistor, JFET/N	23406-101	NAT	J113	SIL	
Card #7 and Card #10						
Capacitors						
C1-3	Polypropylene, 50V, 1%; 0.01uF	21701-310	NOB	CQ15P1H103FPP	WES	
C4	Polypropylene, 50V, 2.5%; 0.068uF	21702-368	NOB	CQ15P1H683GPP		
C5	Polypropylene, 50V, 1%; 0.01uF	21701-310	NOB	CQ15P1H103FPP	WES	
C6	Polypropylene, 50V, 2.5%; 2200pF	21702-222	NOB	CQ15P1H222GPP	WIM	
C7	Polypropylene, 50V, 1%; 0.01uF	21701-310	NOB	CQ15P1H103FPP	WES	
C8	Polypropylene, 50V, 2.5%; 0.068uF	21702-368	NOB	CQ15P1H683GPP		
C9	Polypropylene, 50V, 2.5%; 2200pF	21702-222	NOB	CQ15P1H222GPP	WIM	
C10	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C11	Polypropylene, 50V, 1%; 0.01uF	21701-310	NOB	CQ15P1H103FPP	WES	
C12	Polypropylene, 50V, 2.5%; 0.068uF	21702-368	NOB	CQ15P1H683GPP		
C13-16	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C17	Mica, 500V, 1%; 160pF	21018-116	CD	CD15-FD161F03	SAN	
C18	Mica, 500V, 1%; 100pF	21018-110	CD	CD15-FD101F03	SAN	
C19,20	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C21	Mica, 500V, 1%; 560pF	21022-156	CD	CD19-FD561F03	SAN	
C22	Mica, 500V, 1%; 2400pF	21022-224	CD	CD19-FD242F03	SAN	
C23	Mica, 500V, 1%; 2700pF	21022-227	CD	CD19-FD272F03	SAN	
C24-28	Mica, 500V, 1%: 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C29	Not Used	---				
C30	Alum., Radial, 25V; 100uF	21206-710	PAN	ECE-A1EV101S		
C31,32	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C33	Mica, 500V, 1%; 100pF	21018-110	CD	CD15-FD101F03	SAN	
C34	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C35	Mica, 500V, 5%; 220pF	21020-122	CD	CD15-FD221J03	SAN	
C36	Polypropylene, 50V, 1%; 0.01uF	21701-310	NOB	CQ15P1H103FPP	WES	
C37,38	Alum., Radial, 25V; 100uF	21206-710	PAN	ECE-A1EV101S	MANY	
C39-42	Monolythic Ceramic, 50V, 20%; 0.1uF	21123-410	SPR	1C25 Z5U104M050B	KEM	

FOOTNOTES:

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SPECIFICATIONS AND SOURCES FOR REPLACEMENT PARTS

OPTIMOD-AM 9100B

Card #6—Transistors
Card #7 and Card #10—Capacitors

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS (1)	NOTES
Card #7 and Card #10 (continued)						
Diodes						
CR11,12	Diode, Signal, Hot Carrier	22102-001	HP	HP5082-2800		
CR14	Diode, Signal, Hot Carrier	22102-001	HP	HP5082-2800		
Inductors						
L1,2	Inductor, Variable	29704-003	ORB			
L3	Inductor, Variable	29704-004	ORB			
Integrated Circuits						
IC1-6	Linear, Dual Opamp	24206-202	TI	TL072CP	MOT	
IC7,8	Linear, Dual Opamp	24202-202	RAY	RC4558NB	MOT,FSC	
IC9	Linear, Dual Opamp	24206-202	TI	TL072CP	MOT	
Modules						
A1	Module Assy, Distortion Cancel Filter	30490-002-xx*	ORB			*Add suffix printed on part
Resistors						
R41	Resistor Set, MF; 20.5K	28521-008	ORB			3
R45,46	Resistor Set, MF; 20.5K	28521-008	ORB			3
R50	Resistor Set, MF; 20.5K	28521-008	ORB			3
R73	Pot, Single, 100K, (5020R)	20736-000	ORB			20% CCW Log
R80	Pot, Single, 10K; (5050)	20720-000	ORB			Linear
Card #8 and Card #9						
Capacitors						
C1	Mica, 500V, 1%; 1000pF	21022-210	CD	CD19-FD102F03	SAN	
C2	Polystyrene, 50V, 2%; 0.0068uF	21504-268	SPR	287P 6822R5A3		
C3,4	Alum., Radial, 50V; 47uF	21208-647	SPR	502D 476G050CD1C	PAN	
C5-8	Monolythic Ceramic, 50V, 20%; 0.1uF	21123-410	SPR	1C25 Z5U104M050B	KEM	
C9,10	Alum., Radial, 25V; 100uF	21206-710	PAN	ECE-A1EV101S	MANY	
C11,12	Met. Polyester, 100V, 10%; 0.1uF	21441-410	WIM	MKS-4100V5.0.1	WES,SIE	
Integrated Circuits						
IC1	Digital, Hex Inverter	24505-302	RCA	CD4069UBE	SIG	
IC2	Linear, Dual Opamp	24209-202	NAT	LF412CN		
IC3	Linear, Dual Opamp	24206-202	TI	TL072CP	MOT	
IC4	Digital, NAND Gate	24501-302	RCA	CD4011BE	MOT	
IC5	Digital, 1-in-4 Decoder	24506-302	RCA	CD4555BE	SIG	
IC6-9	Optoisolator, NPN	25003-000	SIE	SFH-601-1		
IC10,11	Linear, Dual Opamp	24207-202	SIG	NE5532N	TI,EXR	

FOOTNOTES:
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SPECIFICATIONS AND SOURCES FOR REPLACEMENT PARTS

OPTIMOD-AM 9100B

Card #7 and Card #10—Diodes, Inductors, Integrated Circuits, Modules, Resistors
Card #8 and Card #9—Capacitors, Integrated Circuits

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS (1)	NOTES
Card #8 and Card #9 (continued)						
Modules						
A1	Module Assy, Tilt Equalizer	30690-000-xx*	ORB			*Add suffix printed on part
Resistors						
R22	Trimpot, Cermet, 20 Turn; 100K	20512-410	BEK	89PR100K	BRN	
R29	Trimpot, Cermet, 20 Turn; 100K	20512-410	BEK	89PR100K	BRN	
Switches						
S1	Switch, Toggle, Min.; DPDT	26041-202	CK	7201SYABE		
Transistors						
Q1-8	Transistor, JFET/N	23406-101	NAT	J113	SIL	
Q9,10	Transistor, Signal, NPN	23202-101	MOT	2N4400	FSC	
CHASSIS (FRONT PANEL)						
LEDs						
CR1-4	LED, Yellow	25105-000	GI	MV-5353		
CR5	LED, Red	25103-000	GI	MV-5053		
CR6	LED, Green	25104-000	GI	MV-5253		
Meters						
NONE	Meter,Edge, 1mA, Cream/Black, 0 to 25	28009-104	EMI	132D5		950 Ohms
NONE	Meter,Edge, 1mA, Cream/Black, +10 to -15	28009-107	EMI	132D5		950 Ohms
NONE	Meter, VU, Brown/Tan	28002-007	DIX	330T	HOYT	
Switches						
S2,3	Switch, Toggle, Min.; SPDT	26044-101	CK	7105P3YZQE		
CHASSIS (POWER SUPPLY)						
Capacitors						
C101,102	Alum., Electrolytic, 40V; 5000uF	21250-850	CD	FAH-5000-40-A2	MAL	
C103,104	Ceramic Disc, 50V, 20%; 0.05uF	21107-350	CRL	UK50-503	MUR	
C105-107	Ceramic, Feed-thru, 1000pF	21118-210	ERE	2404-000	MUR	

FOOTNOTES:
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(4) Realignment may be required if replaced, see Circuit Description and/or Alignment Instructions

SPECIFICATIONS AND SOURCES FOR REPLACEMENT PARTS
OPTIMOD-AM 9100B
Card #8 and Card #9–Modules, Resistors, Switches, Transistors
Chassis (Front Panel)–LEDs, Meters, Switches
Chassis (Power Supply)–Capacitors

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS (1)	NOTES
Chassis (continued)						
Diodes						
CR101-104	Diode, Rectifier, 400V, 3A	22203-400	MOT	MR504		
Inductors						
L101,102	Inductor, RF Choke, 7uH	29501-004	OHM	Z-50	(2)	
Miscellaneous						
F101	Fuse, 3AG, slow-blow, 1/2A	28004-150	LFE	313.500	BUS	1/4" x 1 1/4" GLASS
T101	Transformer, Power; 38VCT, 46VA	55009-000	ORB			
Switches						
S101	Switch, Rocker, Power, DPST	26003-001	MAR	1802-0111		
S102	Switch, Slide, Mains voltage selector	26140-000	SW	EPSI-SLI		
CHASSIS (REAR PANEL)						
Capacitors						
C1-23	Ceramic, Feed-thru, 1000pF	21118-210	ERE	2404-000	MUR	
Miscellaneous						
FL101	Filter, Line, 3 Amp	28015-000	COR	3EF1		
INPUT FILTER ASSEMBLY						
Capacitors						
C1-8	Ceramic Disc, 1KV, 10%; 0.0015uF	21112-215	CRL	DD-152	MUR	
Inductors						
L1-14	Inductor, RF Choke, 1.2mH	29503-000	MIL	73F123AF		
L15	Inductor, RF Choke, 7uH	29501-004	OHM	Z-50	(2)	
METER RESISTOR BOARD						
Switches						
S1	Switch, Rotary, 1P12T	26078-306	CTS	212-Series		

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

SPECIFICATIONS AND SOURCES FOR REPLACEMENT PARTS

OPTIMOD-AM 9100B

Chassis (Power Supply)–Diodes, Inductors, Misc, Switches
Chassis (Rear Panel)–Capacitors, Misc.
Input Filter Assy–Capacitors, Inductors
Meter Resistor Board–Switches

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS(1)	NOTES
MONITOR ROLLOFF FILTER (ACCESSORY)						
Capacitors						
C1	Met. Polyester, 100V, 5%; 0.034uF	21440-334	WES	60C 343J250	SIE,WIM	
C2	Met. Polyester, 100V, 5%; 0.29uF	21440-429	WES	60C 294J100	SIE,WIM	
C3	Met. Polyester, 100V, 10%; 0.039uF	21441-339	WES	60C 393K250	SIE	
C4a,b	Capacitor Set, 100V, 0.27uF	28604-001	ORB			3
C5	Met. Polycarb., 100V, 2%; 0.15uF	21602-415	ECI	652A 1B154G	IMB	
Inductors						
L1	Inductor, Variable	29703-002	ORB			
L2	Inductor, Variable	29706-002	ORB			
Resistors						
R4	Pot, Single, 500 OHM, (5050)	20747-000	ORB			Linear
Switches						
S1	Switch, Slide, DPDT (Gold)	26106-000	CW	GF326-0149		Special Plating
OTHER						
Miscellaneous						
NONE	Line Cord, CEE	28102-002	BEL	17500	MANY	
NONE	PCB Extender Board Assy	30705-000	ORB			
POWER SUPPLY BOARD						
Capacitors						
C108	Tantalum, 10V, 10%; 33uF	21303-633	SPR	196D 336X9010KE3	MANY	
C109	Mica, 500V, 5%; 470pF	21024-147	CD	CD19-FD471J03	SAN	
C110	Not Used	---				
C111,112	Alum., Radial, 50V; 47uF	21208-647	SPR	502D 476G050CD1C	PAN	
C113	Mica, 500V, 5%; 100pF	21020-110	CD	CD15-FD101J03	SAN	
C114	Polyester, 100V, 10%; 0.01uF	21401-310	SPR	225P 10391WD3	PAN,PAK	
Diodes						
CR105,106	Diode, Rectifier, 400V, 1A	22201-400	MOT	1N4004	MANY	
VR101,102	Diode, Zener, 5W; 16V, 5%	22005-160	MOT	1N5353B	MANY	

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

SPECIFICATIONS AND SOURCES FOR REPLACEMENT PARTS

OPTIMOD-AM 9100B

Monitor Rolloff Filter (Assy)-Capacitors, Inductors, Resistors, Switches
Other-Misc
Power Supply Board-Capacitors, Diodes

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS (1)	NOTES
Power Supply Board (continued)						
Integrated Circuits						
IC101	D.C. Regulator	24301-302	NAT	LM723CN		
IC102	Linear, Single Opamp	24003-202	NAT	LM301AN	TI,RCA	
Miscellaneous						
F102,103	Fuse, Pico, 1A, Axial	28011-210	LFE	275001	BUS	
Resistors						
R103,104	Resistor, Wirewound, 2W, 0.62 OHM; 5%	20028-862	IRC	BWF Series		
R106	Trimpot, Cermet, 18 Turn; 500 OHM	20508-150	BEK	68XR500	BRN	
R108,109	Resistor Set, MF; 20.5K	28521-008	ORB			3
Transistors						
Q101,102	Transistor, Power, NPN; TO-204MA/TO-3	23601-501	RCA	2N3055	FSC	Located on Chassis Rear Panel
Q103,104	Transistor, Signal, PNP	23002-101	MOT	2N4402	FSC	
TILT EQ AUX. BOARD (ON CARD #8)						
Capacitors						
C21-24	Met. Polyester, 100V, 10%; 0.1uF	21441-410	WIM	MKS-4100V5.0.1	WES,SIE	
Integrated Circuits						
IC21,22	Linear, Dual Opamp	24209-202	NAT	LF412CN		
Transistors						
Q21-24	Transistor, JFET/N	23406-101	NAT	J113	SIL	

FOOTNOTES:
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SPECIFICATIONS AND SOURCES FOR REPLACEMENT PARTS

OPTIMOD-AM 9100B

Power Supply Board–Integrated Circuits, Misc, Resistors, Transistors
Tilt Eq. Aux. Board–Capacitors, Integrated Circuits, Transistors

Vendor Codes

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

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

AKG AKG Acoustics, Inc.
1525 Alvarado Street
San Leandro, CA 94577

AM Amphenol Corporation
358 Hall Avenue
Wallingford, CT 06492

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

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

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

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

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

CRL Mepcopal/Centralab
See Mepcopal

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

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

CW CW Industries
130 James Way
Southampton, PA 18966

DBX dbx
A division of AKG Acoustics, Inc.
1525 Alvarado Street
San Leandro, CA 94577

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

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

ELSW Electro Switch
77 King Avenue
Weymouth, MA 02188

EMI Crompton Modutec
920 Candia Rd.
Manchester, NH 03109

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

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

FSC Fairchild Camera & Instr. Corp.
See National Semiconductor

GI General Instruments
Optoelectronics Division
See Quality Technologies

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

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

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

INS Intersil, Inc.
See Harris Semiconductor

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

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

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

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

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

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

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

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

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

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

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

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

MOT Motorola Semiconductor
PO Box 20912
Phoenix, AZ 85036

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

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

NEL Crystal Biotech
75 South Street
Hopkinton, MA 01748

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

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

OHM Ohmite Manufacturing Company
3601 Howard Street
Skokie, IL 60076

ORB Orban
A division of AKG Acoustics, Inc.
1525 Alvarado Street
San Leandro, CA 94577

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

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

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

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

RCA RCA Solid State
See Harris Semiconductor

ROHM Rohm Electronics
3034 Owens Dr.
Antioch, TENN 37013

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

SAN Sangamo Weston Inc.
Capacitor Division
See Cornell-Dubilier

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

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

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

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

SW Switchcraft
A Raytheon Company
5555 N. Elston Avenue
Chicago, IL 60630

TAI Taiyo America, Inc.
700 Frontier Way
Bensenville, IL 60106

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

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

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

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

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

WES Westlake
See Mallory Capacitor Co.

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

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

Schematics, Assembly Drawings

The following drawings are included in this manual:

These drawings reflect the actual construction of your unit as accurately as possible. Any differences between the drawings and your unit are most likely due to product improvements or production changes since the publication of this manual. Major changes are described in addenda located at the front of this manual. If you intend to replace parts, please read page 6-43.