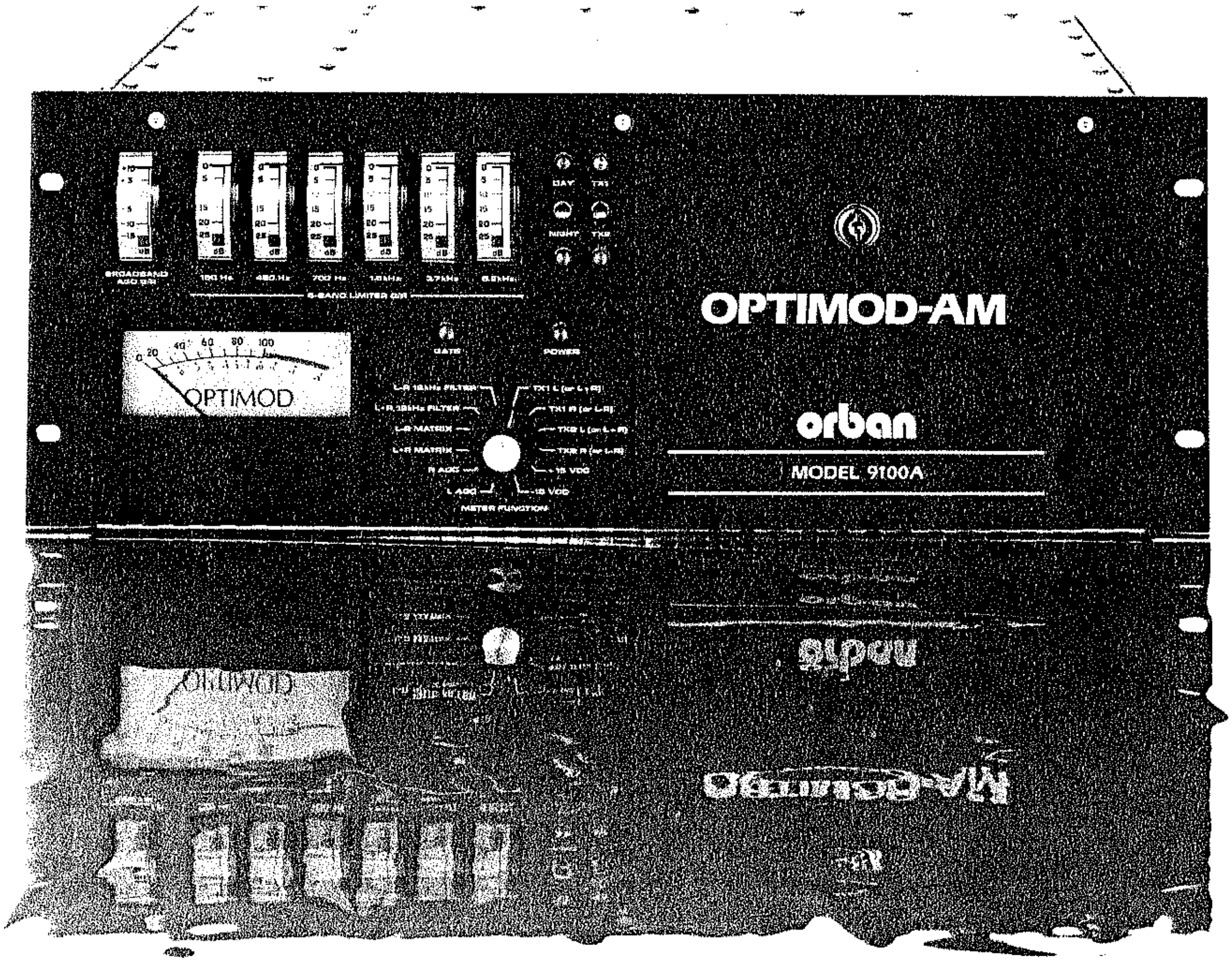
THIRD EDITION

Operating Manual

9100A OPTIMOD-AM



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Addendum #1
to OPTIMOD-AM® Operating Manual
Third edition, P/N 95032-000-03

This addendum supplements the discussion of the HF Equalizer modules in recognition of the introduction of the BLUE module, which facilitates conformance to the newly developed National Radio Systems Committee (NRSC) standard for AM pre-emphasis. This BLUE module is now installed at the factory, but we continue to include the older RED, YELLOW, and GREEN modules mentioned in the 9100A Operating Manual for stations which prefer other HF equalization.

It is suggested that the reader mark each of the following passages "See Addendum 1" for future reference. It might be best to review those passages before reading this addendum.

Introduction, page 1-4: "High Frequency Equalizer"
Installation, page 3-10: "Option 7: HF Equalizer Modules"
Operating Instructions, page 5-7: "On High Frequency Equalization"

Your receipt of this addendum with your OPTIMOD-AM indicates that the BLUE module is installed in that unit. If you have another OPTIMOD-AM with a serial number below 990000, you may obtain the BLUE module by contacting Orban Customer Service at the number shown on the title page.

Operating Instructions

Alternate Equalizer Modules

(Including the new BLUE module for NRSC-standard modified 75-microsecond pre-emphasis.)

The Pre-emphasis Dilemma

Certain AM receivers manufactured since 1984 (particularly those designed for domestic AM stereo reception) have a frequency response which is substantially wider than that of the typical mono AM receiver. This was done largely to enhance the sales potential of AM stereo by presenting a dramatic, audible improvement in fidelity in the showroom. (Some receivers actually switch to a narrow bandwidth whenever the receiver is set to mono – apparently for no other reason than to make the mono reception sound comparatively poorer!)

As these new receivers became more prevalent, broadcasters had to choose whether the station's high-frequency equalization (pre-emphasis) would be optimized for the new AM stereo receivers or for conventional receivers (the vast majority of the market), or perhaps set for some middle compromise.

If the choice was for conventional receivers (which implies a relatively extreme pre-emphasis), the newer receivers may sound strident or exceptionally bright unless their tone controls (if present) are turned down or the receiver is switched to "narrowband" by the user.

If the choice favored the newer receivers (less pre-emphasis and probably less processing), the majority of receivers will be deprived of much high-end energy and will sound both quieter and duller than they would with pre-emphasis and processing optimized for their characteristics.

NRSC Standard Pre-emphasis

In response to this dilemma, the National Radio Systems Committee (NRSC) undertook the difficult task of defining a voluntary recommended pre-emphasis curve for AM radio that would be acceptable to broadcasters (who want the highest quality sound on the majority of their listeners' radios) and to receiver manufacturers (who are primarily concerned with interference from a co-channel or from first- and second-adjacent stations).

After a year of deliberation, a "modified 75-microsecond" pre-emphasis/de-emphasis standard was approved (see figure 2). This provides a moderate amount of improvement for existing narrowband radios, while optimizing the sound of wideband radios. Most importantly, it minimizes generation of first-adjacent interference much better than do steeper pre-emphasis curves. The radio manufacturers participating in the NRSC stated that such reduction in interference *must be demonstrated by broadcasters* before receiver manufacturers would be willing to release true wideband (10kHz audio bandwidth) receivers to the mass market. This is rational – the receiver manufacturers can lose millions of dollars if they produce receivers that are rejected as noisy or interference-prone by consumers. In contrast, broadcasters can easily change pre-emphasis with very little expense.

Implementation

To make changes in pre-emphasis convenient, all OPTIMOD-AMs with a serial number of 700000 or higher have been shipped with a 16-pin socket factory-installed on Cards #4 and #5. (Card #5 is present only on the stereo versions, Models 9100A/2 and 9100A/2C). Each such unit has been supplied with a set of color-coded equalization modules that plug into this socket. Since serial number 990000, the BLUE (NRSC) module has been installed in the socket(s) at the factory, with the others packed in a plastic container enclosed in the shipping carton.

Choosing the "Right" Module

The **BLUE module** provides the NRSC recommended pre-emphasis curve when the 9100A's HF EQ control is turned fully clockwise. Although this standard is voluntary, we *strongly recommend* the BLUE (NRSC) module, because we are convinced that use of this more modest pre-emphasis by broadcasters is the only thing that will eventually induce the receiver manufacturers to build and mass-market the high-fidelity, wideband radios which would allow AM stations to compete with FM in audio quality. The commitment to do so was strongly expressed by the receiver manufacturers involved in the NRSC's deliberations. The ball is now clearly in the broadcasters' court.

(On narrowband radios the BLUE module may produce a somewhat duller sound than the other modules, but narrowband radios with asymmetrical IF slopes due to normal manufacturing tolerances will tend to sound less distorted.)

Three other modules are included because the new standard is voluntary and because some broadcasters may have different requirements or preferences:

The **RED module** is reasonably compatible with both the new wideband radios and the older narrowband radios. It will tend to produce more first-adjacent channel interference than the BLUE module. Its sound is generally brighter than the BLUE module.

The **GREEN module** provides the same equalization originally supplied as standard with early OPTIMOD-AMs (in the black epoxy module). Compared to the other modules, it provides much more boost in the 5kHz region, and tends to sound strident on the new wideband radios. The radios that can gain significant benefit from this module are vanishing. Its benefit is only 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. We can, therefore, no longer recommend it.

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

Changes in the 9100A Operating Manual Due to Installation of Modules

1) In the recommended **Initial Control Adjustments** in Part 4 (page 4-7) of the Operating Manual, the HF EQ control should be turned fully clockwise if the BLUE module is used. The processor will then produce the pre-emphasis curve recommended by the NRSC. If you use any of the other modules, set the control for 17dB (the "tic" mark between "15" and "20") or less.

2) The **ACC-07 monitor roll-off filters** supplied with 9100A units were designed to complement the original GREEN module, and exist only to facilitate aesthetically pleasing off-the air monitoring where required (see Part 2 of the Manual). These filters were not intended to represent the response of any real AM radio.

   When either the YELLOW or RED modules are used, the monitor roll-off filter will cause a reduction in subjective presence. In most cases, this will still be acceptable for monitoring purposes.

   If the BLUE module is used, a simple "modified 75μs de-emphasis filter" can be placed between the audio output of the modulation monitor and the input of the monitor amplifier to accurately simulate a "standard" NRSC receiver. Fig. 3 provides a schematic and details for constructing such a filter.

   If a subjectively different sound is desired for the off-the-air monitoring, the monitor can be equalized by a graphic or parametric equalizer to taste. Please note that such a monitor will not necessarily reflect accurately the sound of the station on a typical radio.

3) **Proof of Performance** (Part 6 of the Manual) is unaffected by this change, since the equalization will have been defeated.

4) **Program equalizer response** will be as specified in Appendix D (page D-3) only if the GREEN module is installed.

5) Since the GREEN module provides the greatest upper midrange boost of the four modules, the **3.7kHz and 6.2kHz G/R meters** may not be as active when using the other modules. However, if the sound of the alternate EQ leads to higher settings of the HF EQ control, then the 6.2kHz band may be more active than before.

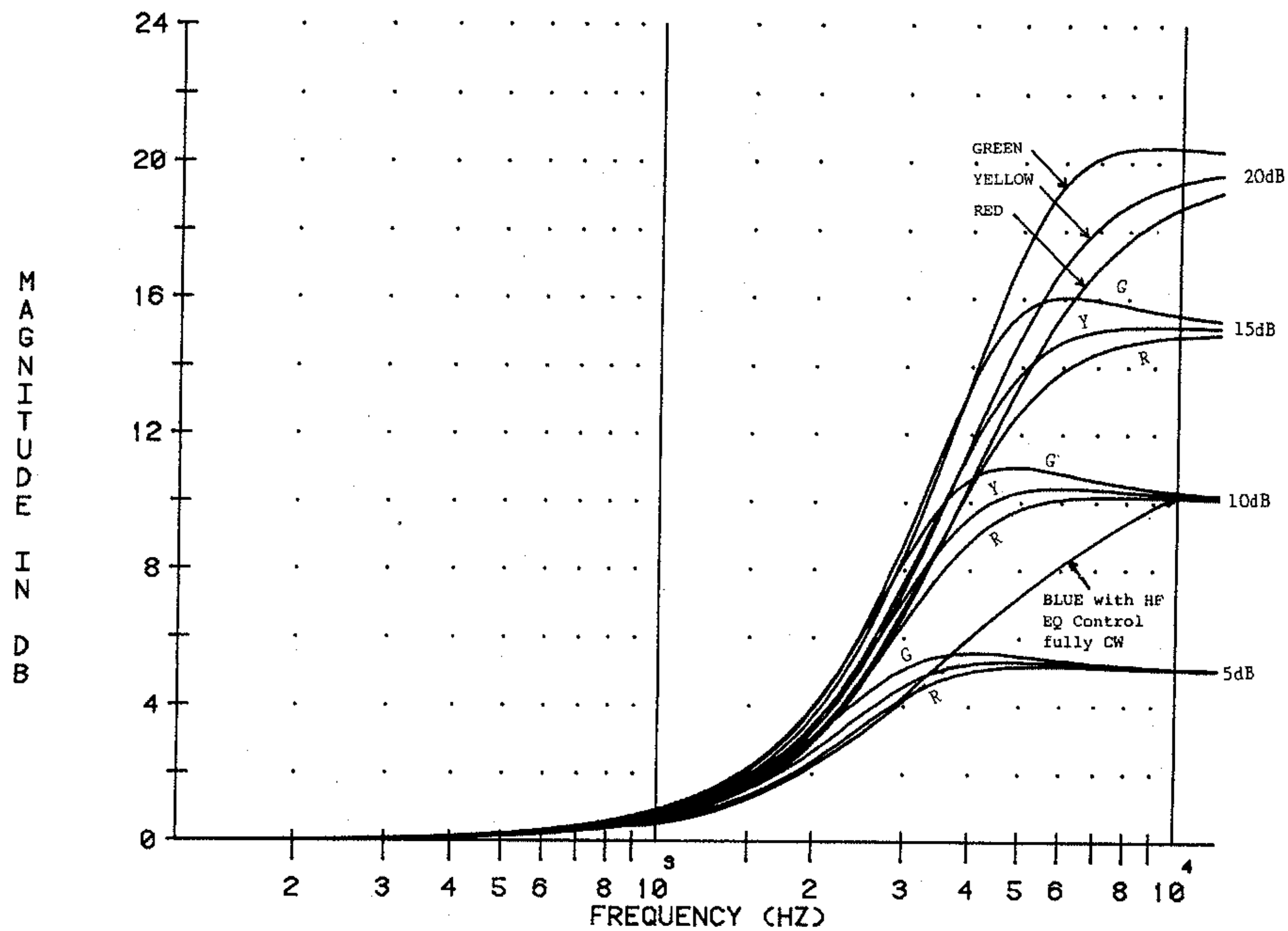

Fig. 1: Curve Families for Alternate Equalizer Modules at four settings of the HF EQ Control

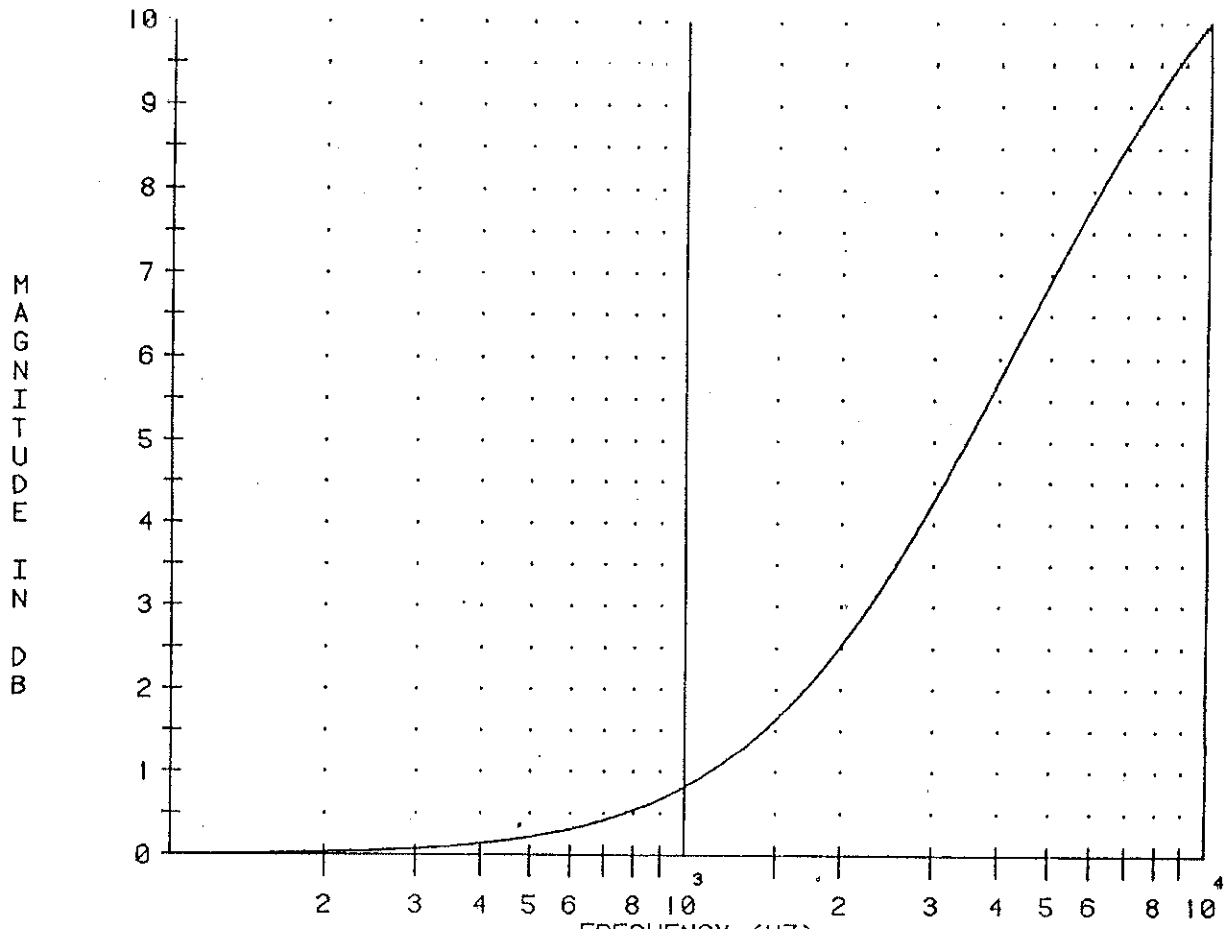

Fig. 2: NRSC Recommended Pre-Emphasis

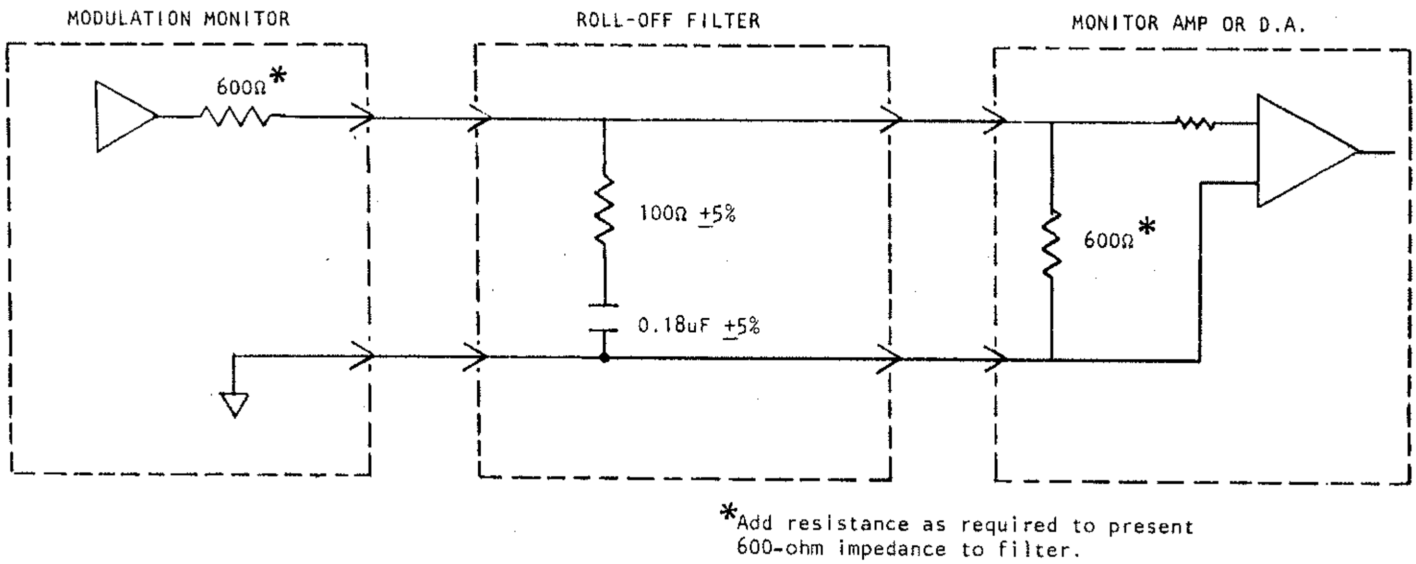

Fig. 3: NRSC Standard Roll-off Filter Schematic

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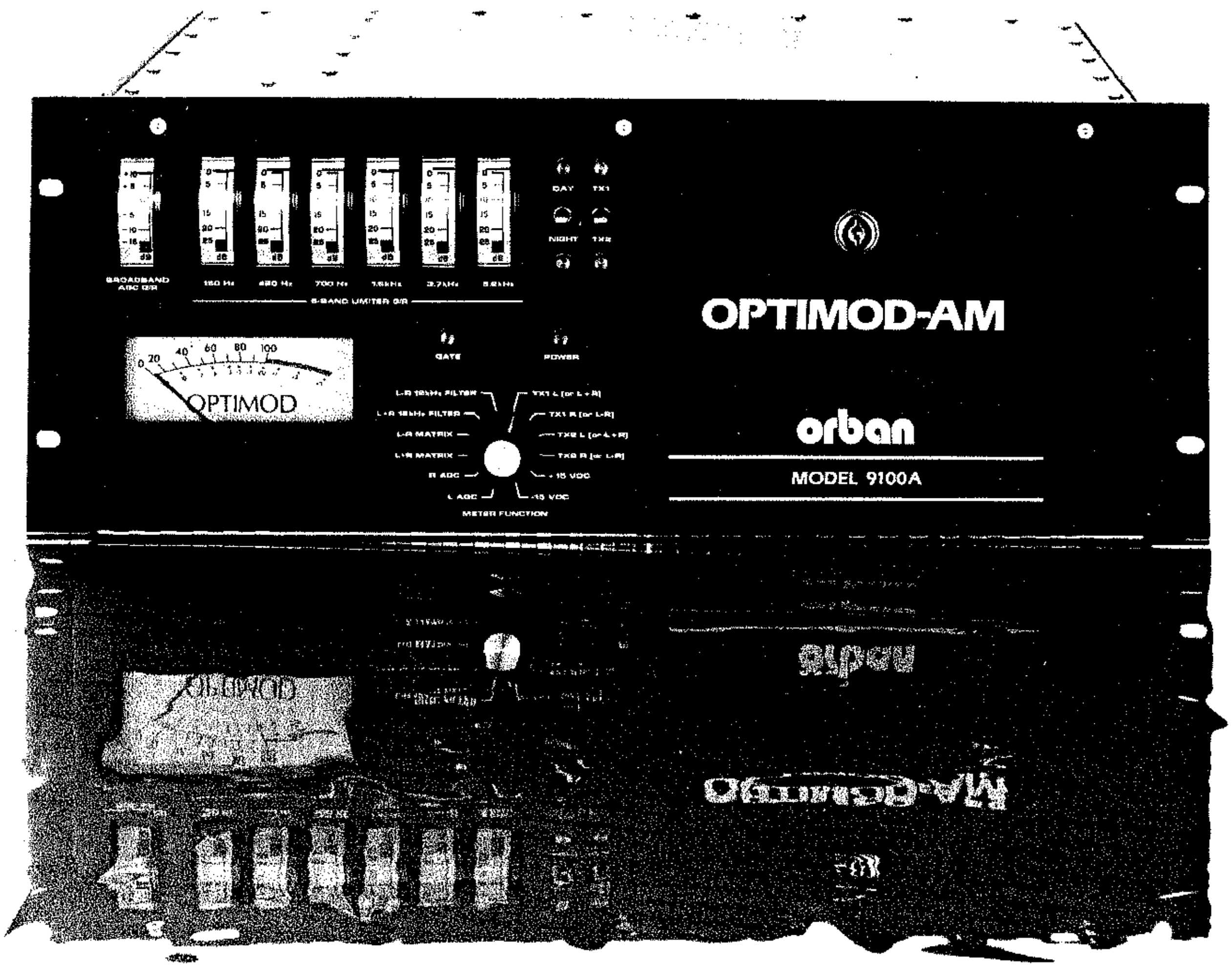

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THIRD EDITION (June 1985)

This edition incorporates revised text which reflects:

-- The inclusion of two Alternate Equalizer Modules which can be installed on Cards #4 and #5 (stereo only) to generate sets of curves which better match the new wider-band stereo receivers.

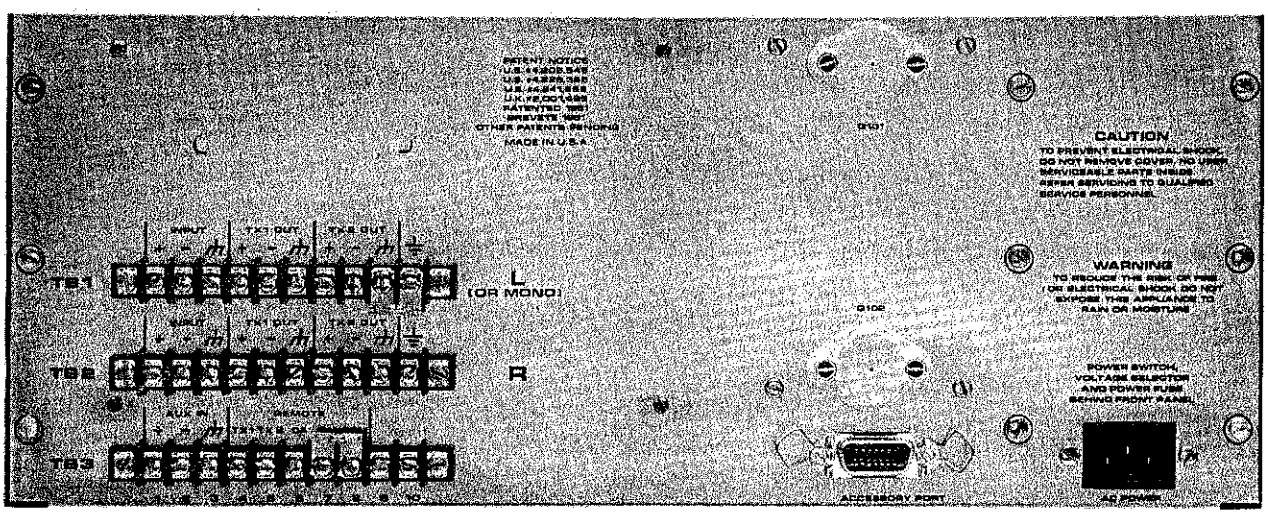
-- The extinction of the Belar, Harris, and Magnavox AM stereo systems -- only Motorola and Kahn remain. References to our Card #1-H (designed for the Harris system), and to our Card #1 (replaced by our new Stereo Enhancement and Compatibility Card #1-S) have therefore been removed. In some places, references to the obsolete Cards #1 and #1-H have been replaced by references to Card #1-S, which is designed to be a universal card for all systems.

-- Additional information about interfacing to the two models of Kahn exciter: the STR-77 and the STR-84.

Other than addition of alternate equalization modules and the new Card #1-S, no changes have been made to the product.

All other changes made to this manual reflect correction of errors, improved presentation, or trivial product improvements not affecting function or specifications.

For information regarding the obsolete Cards #1 and #1-H consult the factory. Certain mono units may be fitted with Optional 5kHz Lowpass Filter Card #1-F which is described briefly in **Part 2 (Application)** of this manual and in a separate manual supplied with that card.



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Preface

This Manual is organized into two major sections. The first contains information on how to plan your installation, how OPTIMOD-AM interfaces with other station equipment, how to set up and adjust OPTIMOD-AM, how to do a Proof of Performance, and brief comments on routine maintenance. You should read Parts 1, 2, and 3 before attempting to install OPTIMOD-AM.

The second section contains Appendices which provide useful information that you may need at some time during the life of OPTIMOD-AM. This is primarily reference material; you do not need to digest it to install, set up, or operate your unit.

There is no Index, so the TABLE OF CONTENTS should be used to help you find the information you want. The TABLE OF CONTENTS provides an overview of the organization of the manual, and lists in some detail the topics discussed.

Registration Card: A Registration Card should have been enclosed with your OPTIMOD-AM. If the card was missing, please photocopy Fig. 1-1 (which duplicates the Registration Card), and send us the filled-in photocopy.

It is important that you return the Registration Card. That way, we can provide you with any applications notes, updates, service bulletins, etc., which may be generated over the life of the product.

Do not allow your Dealer to submit the card for you. If he forgets, you can miss important future mailings and may be delayed in obtaining Warranty service.

Model # ______________________ Serial # ____________

Name or Title ______________________

Organization ______________________

Street ______________________

City/State/Country ______________________

Zip or Mail Code ______________________

Purchased from ____________ City ____________ Date of Purchase ____________

Nature of your application ______________________

How did you hear about it? ______________________

Comments: ______________________

____

Fig. 1-1: Registration Card

Packing Material: The carton in which your OPTIMOD-AM was shipped was carefully designed to prevent damage from the stresses ordinarily encountered in commercial shipping. SAVE THE CARTON AND ALL PACKING MATERIAL in case you ever have to ship the OPTIMOD-AM chassis back to the factory for service.

Security (Keys and Locks): To control access to the setup controls, the access door is fitted with a lock. Two keys are supplied. These can be duplicated as desired.

The dealer from whom your 9100A was purchased can supply additional keys, as can the factory. In either case, your Registration Card must be on file at the factory, and you must supply your serial number to obtain replacement keys.

If all keys are lost, you can obtain access by removing the three hex-socket screws from the top of the main front panel with a 5/64" hex wrench (one was supplied with the unit).

If you wish to make the unit's adjustments more secure, obtain similar splined-socket or aircraft tri-point screws (and tools), and use these in place of the hex-socket screws supplied. (Tools for these are not commonly found in hardware stores or other places D.J.'s might frequent.) The screws are 6-32 x 3/8" 82 degree Flat-Head, nickel-plated steel.

The factory can supply locks which have different keying and which can be rekeyed in the field as desired.

Part 1:
Introduction and System Description

Function Of OPTIMOD-AM: OPTIMOD-AM is a powerful system for obtaining the best possible quality from the AM broadcast medium. This medium includes the station's transmission system plus the listener's receiver, listening environment, and ear.

The OPTIMOD-AM 9100A system is designed for universal application in domestic and international LW, MW, and SW services. While OPTIMOD-AM is ordinarily shipped with a 12kHz output bandwidth to comply with FCC (U.S.A.) specifications for the U.S. MW broadcast service, an optional 5kHz bandwidth-limiting filter card may be plugged into the system to conform its output spectrum to EBU and other standards, or to resolve unusual adjacent channel interference problems.

OPTIMOD-AM is available in two versions: a stereo version (9100A/2) which processes by the "sum-and-difference" method to yield ready compatibility with any proposed AM Stereo system, and a mono version (9100A/1) which can be field-converted to stereo by plugging in three additional circuit cards. No "Stereo Accessory Chassis" is required.

By performing the following functions, the OPTIMOD-AM system delivers a louder, cleaner, brighter, FM-like sound whose open, fatigue-free quality attracts listeners and holds them:

1. It rides gain over a range of as much as 25dB, compressing dynamic range and compensating for gain-riding errors on the part of operators and for gain inconsistencies amongst automation tapes. The amount of dynamic range reduction is adjustable.

2. It increases the density and loudness of the program material by means of multiband limiting and multiband distortion-cancelled clipping, achieving remarkable increases in loudness and definition without audible side-effects.

3. It compensates for the high- and low-frequency rolloffs of typical AM receivers by means of a statistically-derived fully-adjustable program equalizer. Up to 22dB of HF boost can be produced above 6kHz. This extreme equalization can be readily handled by the processing without the side-effects encountered in conventional processors.

4. It reliably controls peak levels to prevent overmodulation.

5. It improves the consistency of the station's equalization texture by means of multiband limiting.

6. It compensates for inaccuracies in the pulse response of transmitters and antenna systems by means of a powerful transmitter equalizer with four adjustable correction parameters. Four complete sets of adjustments may be preset and recalled as needed by remote control.

7. It controls the bandwidth of the transmitter emissions as necessary to meet the specifications of government authorities, regardless of program material or equalization settings.

8. (9000A/2 Only) It provides complete stereo processing by the "sum-and-difference" method, correctly controlling the peak modulation of the AM envelope in AM Stereo service.

OPTIMOD-AM's Application To Your System: Each part of the OPTIMOD-AM system has been precisely engineered to be compatible with all other parts to achieve optimum performance. For this reason, OPTIMOD-AM should be fed unprocessed audio. NO OTHER AUDIO PROCESSING IS DESIRABLE, OR NECESSARY.

Because of OPTIMOD-AM's extreme versatility, it is very important that the sections of this manual regarding setup and adjustment be read and carefully understood. It will be seen that the OPTIMOD-AM system has many conceptual similarities to conventional systems consisting of a compressor, graphic equalizer, and peak limiter. This should help you understand the system. But beware of significant unfamiliar innovations: they can work for you if you understand them, or against you if you don't.

IMPORTANT!

ASSUME NOTHING! IN PARTICULAR, DON'T ASSUME THAT OPTIMOD-AM's SUPERFICIAL SIMILARITY TO CONVENTIONAL SYSTEMS MEANS THAT IT CAN BE TREATED IDENTICALLY. BEST RESULTS CAN ONLY BE OBTAINED BY READING AND UNDERSTANDING THIS MANUAL.

The primary goal in the design of OPTIMOD-AM was to create processing that would achieve an "FM-like" sound at the listener's ear by pre-processing for the limitations of the average auto or table radio in such a way that audible side-effects are avoided, and that no compromises are made in loudness or coverage.

Such a pre-processed signal requires that the source material applied to the OPTIMOD-AM input terminals be of very high quality, because defects ordinarily lost in the usual sea of "AM mud" suddenly become startlingly audible. For this reason, it is necessary to bring the audio plant up to FM standards of frequency response, distortion, and noise. **Appendix K** provides some specific suggestions on how to do this.

In addition, the extremely high average power of the OPTIMOD-AM-processed signal, plus its HF preemphasis, put extreme demands upon the performance of the transmitter and antenna system. While improved results can be expected from most plants, outstanding results are only achieved from plants with transmitters which can accurately reproduce the OPTIMOD-AM output, and with wideband, symmetrical antenna arrays.

These considerations are discussed in more detail below.

About Stereo: The FCC (U.S.A.) has decided that the marketplace should determine which AM stereo system is to prevail, provided any such system meets certain minimum performance standards set forth in the FCC's Report And Order dated March 18, 1982. Because of the current confusion over standards, we are able to provide only general instructions for using OPTIMOD-AM for AM Stereo.

AM stereo, with or without OPTIMOD-AM, is an inherently tricky proposition and will not, in any station, be successful without a considerable amount of real engineering input. It is by no means as easy as FM stereo!

There are serious considerations involving the station's transmitter and antenna. There is a current lack of precise information as to the characteristics of the exciters for the various systems. Different systems have varying amounts of sensitivity to certain parameters (see **AM Stereo** in **Part 2: Various Application Notes,** below).

SIMPLIFIED SYSTEM DESCRIPTION

This section provides a description of the OPTIMOD-AM system sufficient to permit full understanding of **Part 2 (Various Application Notes)** and **Part 3 (Installation)** below. More detailed discussions of the system from the point of view of troubleshooting and maintenance are found in **Appendix A (System Description),** and **Appendix B (Circuit Description).**

REFER TO THE FOLD-OUT BLOCK DIAGRAM AT THE BACK OF THIS MANUAL.

The audio signal path through OPTIMOD-AM consists of seven basic cascaded sections. These are:

1) INPUT BUFFER AND CONDITIONING FILTER
2) BROADBAND GATED AGC/NOISE GATE
3) MAIN PROGRAM EQUALIZER
4) SIX-BAND LIMITER
5) MULTIBAND DISTORTION-CANCELLED CLIPPER
6) OUTPUT LOWPASS FILTER AND SAFETY CLIPPER.
7) TRANSMITTER EQUALIZER AND OUTPUT AMPLIFIER
8) STEREO ENHANCEMENTS (9100A/2 ONLY)

A DESCRIPTION AND DISCUSSION OF EACH OF THE BLOCKS FOLLOWS.

1) Input Buffer And Conditioning Filter: The active-balanced input buffer amplifier receives the signal from the phone line or STL and amplifies it to the point where the rest of the system is operated in the optimum part of its range. The INPUT LEVEL control determines the gain of the buffer, and thus the amount of gain reduction produced by the next section, the Broadband AGC.

The conditioning filter performs three separate functions:

1) It highpass-filters the input signal at 50Hz at a rate exceeding 18dB/octave, and includes a deep 25Hz notch for automation cuetones;

2) It lowpass-filters the input signal at 12kHz at 24dB/octave;

3) It scrambles the phase of the input signal to make asymmetrical input signals (such as voice) more symmetrical, making best use of the processing to follow.

2) Broadband Gated AGC/Noise Gate: The Broadband AGC compresses the dynamic range of program material and compensates for operator sloppiness so that subsequent sections are driven with optimum audio levels. In this way consistent sound is achieved despite normal production variations. The Broadband AGC is not designed to produce significant augmentation of program density; such augmentation is produced far more effectively by the Six-Band Limiter which follows.

Accordingly, the Broadband AGC's attack time and release time are slow at all times (SINGLE TIME CONSTANT mode), or slow except when large changes of level have occurred (MULTI TIME CONSTANT mode). SINGLE TIME CONSTANT mode ordinarily sounds best, but MULTI may be useful in talk formats where wide variations in input level are encountered.

To avoid audible noise pump-up (because of the slow release time), the gain of the Broadband AGC is held approximately constant if its input level falls below a user-adjustable GATING THRESHOLD level. [If the input level is below the gate threshold for a long period of time, the gain of the Broadband AGC will slowly drift to 10dB gain reduction (zero on the G/R meter).] The gating threshold level detector is bandlimited from 100 to 3000Hz to prevent false ungating on noise.

The amount of gain reduction provided by the Broadband AGC is adjusted with the INPUT LEVEL control; a 25dB range is available. The G/R is continuously indicated on the BROADBAND AGC G/R meter on the front panel. The INPUT LEVEL control should be set conservatively so that screaming D.J.'s and pegged console VU meters do not force the BROADBAND AGC G/R meter offscale.

3) Main Program Equalizer: The main Program Equalizer consists of two sections: bass and high frequency. The available curves provided by these sections have been carefully selected to readily enable effective correction of the frequency response limitations of conventional AM receivers. More than 20dB of equalization is available at 10kHz. Ordinarily, use of such large amounts of equalization would cause severe difficulties in the audio processing equipment following the equalizer. However, the audio processing in the OPTIMOD-AM has been specially designed to deal with such equalization. The Six-Band Limiter section which follows acts as an unusually effective high frequency limiter; the program-controlled release time circuitry permits as much as 25dB compression of a given high frequency band without audible side effects. "Mud" and "grit" caused by intermodulation products below 1.8kHz is reduced up to 40dB by sophisticated circuitry in the multiband distortion-cancelled clipper. Thus peaks and spikes caused by high frequency preemphasis can be clipped, avoiding the pumping that would result if gain reduction were used instead of clipping.

A description of the equalizer sections follows:

Bass Equalizer: The bass equalizer provides a peaking boost. This equalizer is "Parametric". This means that continuously variable control is provided over the amount of peak equalization (0 to +6dB), bandwidth ("Q"= 0.3 to 1.4), and tuning (maximum peak boost frequency variable from 70 to 110Hz).

High Frequency Equalizer: The high frequency equalizer is based upon a statistical study of fifteen common U.S., European, and Japanese auto and table radios from the early 1980's. It was determined that the average response is that given in the left-most curve of Fig. 1-3, and that the standard deviation from the curve is low enough to make synthesis of a complementary preemphasis valid.

Certain AM receivers manufactured in 1984 and after, particularly those designed for AM stereo reception, have a frequency response which is substantially wider than the "average" mono receiver. This was done largely to enhance the sales potential of AM stereo by presenting a dramatic, audible improvement in fidelity in the showroom. (Some receivers actually force the bandwidth into "narrow" whenever the receiver is set to "mono" apparently for no other reason than to make mono reception sound comparatively poorer!)

As these new receivers become more prevalent, each broadcaster will have to choose whether his high frequency equalization (i.e., preemphasis) will be optimized for the vast majority of conventional receivers in his market, or for the new AM stereo receivers, or will be compromised somewhere in between.

If the choice is for the majority (which implies a relatively extreme preemphasis), the new receivers may sound strident or exceptionally bright unless their tone controls (if present) are turned down or they are switched into "narrowband" mode by the user.

If the choice favors the newer receivers, (implying less preemphasis and probably less processing), the majority of receivers will be deprived of much high-end energy and will sound both quieter and duller than they would with preemphasis and processing optimized for their characteristics.

This situation leaves both stereo and mono stations with a dilemma, arising from the continuing absence of a standard frequency response for transmitters and receivers. Accordingly, we are presently providing a marketplace choice for equalization in the form of three plug-in modules (supplied). The GREEN (standard; as-shipped) module is optimized for the "average" narrowband mono receiver. When the HF EQUALIZATION control is fully clockwise, then the GREEN module provides the exact inverse of this receiver response curve up to approximately 5kHz. By 6kHz, it falls below the ideal preemphasis curve by 3dB, and flattens out above that frequency to avoid introducing excessive HF boost which could cause tuning difficulties in receivers and problems in subsequent processing.

The RED module reduces 5kHz energy by comparison to the GREEN module and is thus more appropriate for the wideband stereo radios. The YELLOW module splits the difference.

Each module permits a different family of curves to be produced to accomodate the needs of different formats and tastes. The amount of HF equalization within a given curve family is adjustable by means of the HF EQUALIZATION control so that it can start rolling off earlier than 6kHz if less HF boost is desired. Fig. 1-2 shows the curves produced at 5, 10, 15, and 20dB boost for each of the three modules. Fig. 1-3 shows what happens when the curves produced by the GREEN module are passed through an "average" receiver. It can be seen that the effective bandwidth of the receiver is increased with increasing HF equalization, but that the effective midrange response stays flat. This behavior is in sharp contrast to the response obtained by boosting the high band of a conventional triband compressor in an attempt to provide receiver equalization. In this case, an undesirable midrange boost is produced as a side-effect.

When the HF EQ control is set to the "tic" mark between "15" and "20" and the GREEN module is installed, the 9100A produces our "Recommended Standard Preemphasis For AM and AM Stereo Broadcast".

(Patents are pending on the circuitry used in the HF Equalizer.)

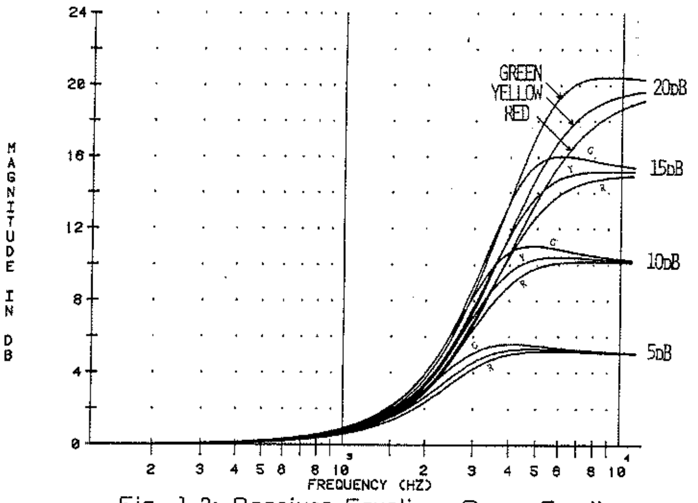


Fig. 1-2: Receiver Equalizer Curve Family

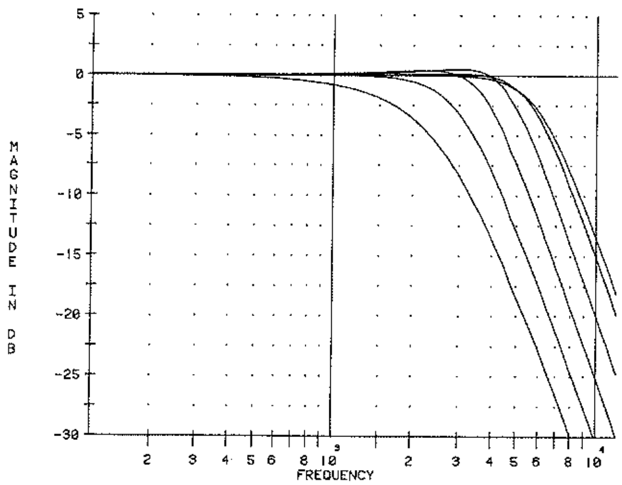


Fig. 1-3: Receiver Equalizer Curve Family Through "Average" Receiver (GREEN Module)

4) Six-Band Limiter: Following the main equalizer, a set of six parallel filters divides the signal into frequency bands. The highest and lowest bands are highpass and lowpass respectively; the other bands are bandpass.

Since the average AM receiver is only flat to about 1.5-2kHz, the midrange is far more important in AM than in FM. Unlike a conventional triband processor, the six bands in OPTIMOD-AM can perform significant correction of midrange frequency balances, yielding a more consistent, intelligible, and pleasing sound with widely varying program material. The six bands are particularly useful in correcting intelligibility problems with low-grade speech from telephone calls or other actualities.

To permit large amounts of limiting without interaction and pumping, the filters have been designed with 12dB/octave slopes. When the filters' outputs are summed after the multiband clipper (which contains further filtering), the resulting output is typically flat ±0.25dB over the frequency range of OPTIMOD-AM. Due to careful computer design of the filters, audible "holes" are not added to the frequency response under dynamic conditions.

Each filter is followed by its own limiter. The characteristics of these limiters are extremely critical if proper frequency response and inaudible operation are to be maintained under dynamic program conditions. For this reason, none of the individual limiter characteristics are user-adjustable. There are two user controls affecting the Six-Band Limiter section: The DENSITY control, which determines the input drive to the entire section, and the CLIPPING control, which adjusts the threshold of limiting of all six limiters simultaneously (controlling the output level of the band-limiters, and thus the drive into the following multiband clipper). Together, the DENSITY and CLIPPING controls determine the amount of multiband limiting produced under operating conditions: Turning the DENSITY control clockwise and/or turning the CLIPPING control counterclockwise will produce more limiting.

The Six-Band Limiter section, because it operates in several frequency bands and exploits the "masking" effect, is capable of far more fast gain control without audible side-effects than the broadband AGC section. We call it the "density augmentation" section because the individual limiters operate with fast release times and 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.

If you are familiar with other multiband audio processing systems, you should be aware that OPTIMOD-AM is fundamentally different in that its multiband section is primarily a limiter, not a compressor. Devices which attempt to perform a compression function with a multiband 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 no gain reduction. Those bands exhibiting heavy gain reduction will, of course, cause an effect similar to a graphic equalizer which is adjusted to severely dip its frequency response in said heavily-compressed bands. This, in turn, can overemphasize those frequencies which have so little energy at the input to the multiband compressor that they cause little or no gain reduction in their bands.

To control such potential problems, average levels into the Six-Band Limiter section are controlled by the slow Broadband AGC so that excessive gain reduction never occurs in the Six-Band Limiter section.

5) Multiband Distortion-Cancelled Clipper: The output of each of the six band-limiters is applied to its own clipper. These clippers are all followed by filters to reduce the out-of-band harmonic and IM distortion caused by the clipping. In addition, the distortion caused by clipping the upper four bands is sharply cancelled below 1.8kHz by means of a feedforward distortion-cancelling sidechain which works in parallel with the main 12kHz lowpass filter.

The result of the distortion filtering and cancellation is an effective reduction of the peak-to-average ratio of the signal without the usual expected distortion buildup due to clipping, yielding an extraordinarily favorable tradeoff between loudness and distortion. A particularly strong advantage of this scheme is that the summed outputs of the six clippers can be applied to a safety clipper for final peak limiting without the need for further broadband gain control, thereby avoiding potential pumping and modulation effects. The complex "Smart Clipper" control circuitry of the older OPTIMOD-AM Model 9000A is therefore not required, yielding a simpler, more cost-effective, and more natural-sounding circuit.

(This scheme is protected by U.S. Patent 4,208,548 and other patents pending.)

6) Output Lowpass Filter And Safety Clipper: The clipping process occurring in the multiband distortion-cancelled clipper causes the addition of harmonic energy above the permissible transmission bandwidth of the AM broadcast system. Because of the heavy clipping usually employed, harmonic energy can reach excessive (and potentially illegal) values, with potential for causing adjacent channel interference. To avoid this, the multiband distortion-cancelled clipper is followed by a phase-linearized 12kHz 5th-order elliptical lowpass filter which also serves as a delay element in the feedforward distortion-cancellation system.

An optional filter card contains three filters: two identical phase-linearized 5kHz 30dB/octave lowpass filters and an all-pass filter (phase delay network) which matches the delay of the 5kHz filters up to their cutoff frequency. FET switches, controlled by logic tied to the DAY/NIGHT status bus (see below), determine whether a 5kHz filter, a delay network, or a bypass amplifier will be inserted after the 12kHz lowpass filter in the L+R/mono audio path. Switches also permit insertion of a 5kHz filter or bypass amplifier at the corresponding point in the L-R audio path (9100A/2 only). Thus any reasonable combination of L+R and L-R bandwidths for DAY and NIGHT are available, and are chosen by moving straps on the optional card. A more detailed discussion is found in the **APPLICATIONS** section of this manual.

The lowpass filter is followed by a safety clipper which simultaneously clips overshoots induced by the lowpass filter and overshoots induced by the addition of the feedforward distortion-correction signal in the multiband distortion-cancelled clipper.

This safety clipper is followed by a supersonic non-overshooting lowpass filter to control potential adjacent-channel interference caused by the action of the safety clipper. Spectrum analysis in our laboratory using both demanding program material and pink noise has verified that the output spectrum of the OPTIMOD-AM meets all interference requirements specified by the FCC (U.S.A.), PROVIDED THAT THE TRANSMITTER ITSELF IS CLEAN AND FREE FROM SIGNIFICANT DISTORTION. (If it is not, then the amount of HF EQ employed in OPTIMOD-AM must be reduced to assure legal occupied bandwidth. This provides a strong incentive for repairing or replacing such a transmitter to achieve maximum benefits from OPTIMOD-AM processing.)

7) Transmitter Equalizer And Output Amplifier: The supersonic lowpass filter drives a three-stage transmitter equalizer. This equalizer predistorts the shape of the final-clipped waveform so that the transmitter modulator will reproduce the intended shape. (If the transmitter distorts the intended shape of the waveform, then overmodulation can occur.)

The first two stages of the equalizer provide correction of the high frequency pulse response of the transmitter/antenna system. An adjustable shelving rolloff eliminates overshoot. Overshoot is further minimized (thus minimizing the required shelving rolloff) by means of a delay equalizer which corrects for nonlinear group delay.

Low frequency tilt is corrected by means of an equalizer which can introduce an adjustable amount of positive-slope tilt to the waveform. The positive-slope tilt cancels the transmitter tilt, permitting accurate reproduction of flat-topped waveforms. Four sets of equalizer controls are provided. These can be switched by remote control for independent equalization of DAY/NIGHT status in each of two transmitters. Two separate memory circuits remember DAY/NIGHT and TX1/TX2 status. The system will always come up in DAY and TX1 mode on powerup. System status is indicated by LED's on the OPTIMOD-AM front panel.

The optional 5kHz filters are switched by the same logic circuitry as the transmitter equalizer controls. If the optional filter card is not installed, the main 12kHz lowpass filter will determine the system output bandwidth at all times, regardless of logic state.

The transmitter equalizer is coupled to the output amplifier through 18-turn screwdriver-adjust OUTPUT ATTEN controls. The output amplifier is an active, balanced configuration capable of driving +20dBm into 600 ohms.

8) Stereo Enhancements (9100A/2 only): The 9100A/2 is equipped with the necessary matrix and dematrix circuits to process stereo audio in the "sum-and-difference" mode, making OPTIMOD-AM compatible with the various AM stereo systems, all of which essentially force the RF envelope (AM component) to equal the sum (L+R) of the two channels to assure compatibility with existing mono receivers using conventional envelope detectors.

The mono OPTIMOD-AM (9100A/1) can be converted to a stereo 9100A/2 by plugging in three circuit cards and other minor work (see **Appendix G: Stereo Conversion**). The chassis is fully wired for stereo, and the unit is equipped with stereo VCA's which have been pre-aligned for correct channel balance and tracking, thus facilitating stereo conversion with minimum fuss.

Understanding the rationale behind the design of the stereo enhancements requires an understanding of the various AM stereo systems. Further discussion is thus postponed until the **Applications** section, below.

This concludes the **SYSTEM DESCRIPTION** section of this manual.

Part 2:
Various Application Notes

This Part of the manual provides essential information on how OPTIMOD-AM fits in with the rest of the equipment in your station.

These notes start with the studio, move through the STL to the transmitter, and finally provide a detailed discussion of AM stereo.

SOURCE QUALITY

It is of vital importance that the source material feeding OPTIMOD-AM be brought up to at least FM standards for distortion, noise, and frequency response. Like any other aggressive, sophisticated audio processing, OPTIMOD-AM processing will exaggerate distortion in the source material. Distortion in the audio plant is thus particularly significant, because immaculately clean audio can be processed far harder than slightly distorted audio before disturbing distortion is noticed by the listener.

Appendix K (Achieving High Source Quality) discusses in some detail the various considerations involved in achieving high audio quality in any radio plant, AM or FM.

USE OF REVERBERATION

In the 1960's, the addition of artificial reverberation was touted as an easy method of achieving higher loudness in AM broadcasting. Given the limitations of the audio processing equipment of that time, this was true: reverberation increased the signal density and average modulation without the pumping or other side effects that heavy limiting would cause if equivalent density were to be achieved by compression or limiting alone.

Reverberation, of course, exacted a price: decreased definition and intelligibility in many instances, because the reverb "smeared" the sound.

OPTIMOD-AM is capable of so much density augmentation by means of its six-band limiter and multiband distortion-cancelled clipper that reverberation is neither necessary nor desirable to achieve high loudness and density. The advantage of OPTIMOD-AM's signal processing is that its processing increases definition and intelligibility, rather than "smearing" it as reverb does.

If you still wish to use reverb to achieve a certain "sound" due to programming considerations, we recommend using it in extreme moderation before the Main Input of OPTIMOD-AM. This is because the processing will effectively increase the amount of reverb by increasing the level of the reverb decay.

REMOTE CONTROL

Five terminals for remote control of DAY/NIGHT and TX1/TX2 status are located on the rear-panel barrier strip. Switching can be effected by applying a pulse of 6-24V AC/DC between the appropriate terminal and "Common".

Local control of DAY/NIGHT and TX1/TX2 status is provided by means of front-panel switches.

USE OF THE AUXILIARY INPUT

The Auxiliary Input provides means to perform split voice/music processing, as well as means to inject EBS tones and/or subsonic telemetry tones.

Split Voice/Music Processing: The Broadband Compressor and Six-Band Limiter sections of OPTIMOD-AM sometimes create less than optimum results with certain types of low-quality speech with substantial background noise, like some noisy telephone conversations or sports remotes. In addition, they tend to "glamorize" announcer vocal quality. Some may like this effect; other may feel that it sounds unnatural.

The solution to such problems lies in use of split voice/music processing. In this application, the front end of OPTIMOD-AM is employed only for music (or for music and high-quality voice). Other voice is processed through its own equalizer, "intelligent" gated compressor, and peak limiter, supplied by the customer. (The Orban 422A/424A Gated Compressor/Limiter/De-esser provides all of these functions except for equalization in a high-performance, economical package, and includes a useful de-esser function which is particularly valuable when used with female voices.) The output of this auxiliary voice processing chain is then introduced to the OPTIMOD-AM Auxiliary Input, where it is mixed with the material fully processed by OPTIMOD-AM. The mix is then applied to the OPTIMOD-AM safety clipper, supersonic lowpass filter, and transmitter equalizer.

Telemetry: The Auxiliary Input provides a convenient input for subsonic telemetry tones. While the Input Conditioning Filter following the Main Input cuts off at 18dB/octave below 50Hz, the response of the Auxiliary Input is essentially flat to below 10Hz. Since the Auxiliary Input is processed by the safety clipper, some intermodulation between the telemetry tones and the audio can occur. Normally, the telemetry receiver contains a limiter which renders it immune to considerable variations in tone level. However, if your telemetry system becomes upset by the level variations, or if audible IM occurs between the subsonic tones and program, the tones can be mixed into the program after the OPTIMOD-AM output. If this is done, be sure that the mixer has a frequency response flat from the lowest frequency telemetry tone to substantially above 12kHz. It is also important that this mixer be phase-linear in this frequency range to avoid distorting peak levels from the OPTIMOD-AM output.

Two-Tone EBS Tests: The Auxiliary Input may also be effectively employed as an input for the two tones used in the EBS test. Fortunately, the two tones are sufficiently close in frequency to prevent the action of the Input Conditioning Filter, the Program Equalizer, and the Six-Band Limiter from seriously disturbing the relative balance between the tones if they are introduced into the Main Input of OPTIMOD-AM.

The 1982 version of the FCC Rules requires each tone to modulate the transmitter at least 40% by itself. No requirement for percentage modulation of the sum is specified. Ordinarily, approximately 45% modulation will be produced by the sum of the tones if they are introduced to the Main Input. This is marginal, and implies that far more reliable results will be achieved if the tones are introduced into the Auxiliary Input.

(The reason that such low modulation is produced by two tones within one band of the Six-Band Limiter is related to the fact that such tones have a very low peak-to-average ratio compared to music. To achieve musically natural results, the processing automatically pushes the peak level of such program material substantially below the peak level of music or speech.)

STUDIO AURAL MONITOR CONSIDERATIONS

Monitor Rolloff Filter: A passive monitor rolloff filter network is included as part of the OPTIMOD-AM system. This is physically located in its own chassis, and is designed to be inserted between the AIR MONITOR output of the modulation monitor and the INPUT of the studio monitoring system. (Two filters are provided with the stereo version of OPTIMOD-AM.)

The rolloff filter provides a deemphasis which is complementary to the preemphasis produced by the OPTIMOD-AM HF Equalizer, producing a big, bright, high-fidelity sound which will boost D.J. morale. If this rolloff filter is not used, the output of the air monitor will sound shrill, strident, and unpleasant because the modulation monitor has a flat response, unlike virtually all real AM radios in the field.

The Monitor Rolloff Filter was designed to complement the standard GREEN module to achieve good subjective results when high-quality monitor speakers are used. When either the RED or YELLOW modules are used, the Monitor Rolloff Filter will cause a reduction in presence as compared to the standard GREEN module. In most cases this will still be acceptable for monitoring purposes. As always, however, the most accurate judgements can be made only on real receivers in typical listening environments.

The rolloff filter is passive. It must be operated unbalanced. The input driving impedance can be either a voltage source (like an opamp output) or 600 ohms. The load impedance can be either 600 ohms or high impedance bridging. When operated between 600 ohm source and load impedances, the insertion loss at 50Hz is -6dB. [See **Installation (Part** 3) for further details.]

After OPTIMOD-AM has been installed and its setup controls adjusted to provide the sound desired on typical radios, the ROLLOFF control(s) on the monitor rolloff filter(s) should be adjusted to create the most pleasing subjective sound in the control room. It should be noted that this sound will be notably brighter than the sound of a typical AM radio, and therefore cannot be used as a reference for adjusting the OPTIMOD-AM receiver equalizer controls. However, it will clearly reveal other problems with audio quality, such as distortion due to excessive clipping, excessive density augmentation, and loss of quality due to problems with the transmitter or other parts of the plant.

If a different tonal balance is desired for off-the-air monitoring, a five-band graphic equalizer may be introduced after the Monitor Rolloff Filter, adjusted to boost the 5kHz region to taste.

Fig. 2-1 shows the frequency response of the rolloff filter at various settings of the ROLLOFF control.

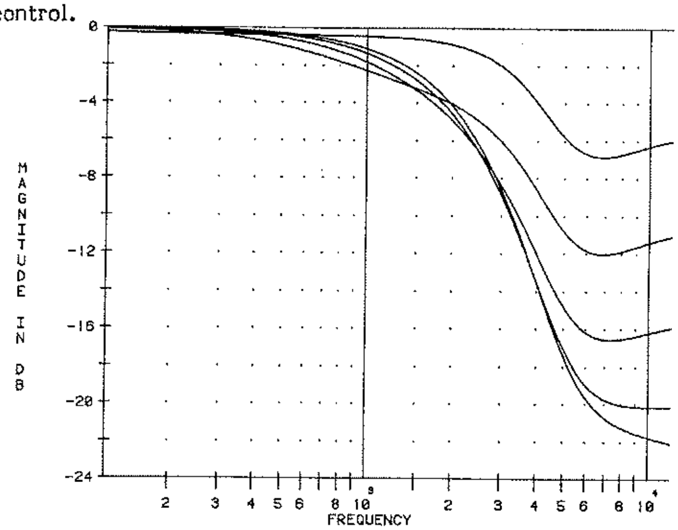


Fig. 2-1: MONITOR ROLLOFF FILTER FREQUENCY RESPONSE

Headphones: Highly processed audio always causes a problem with D.J. headphones. If the phones are fed directly from the air monitor, the headphone sound will be fatiguing and strident, and will tend to cause high frequency acoustic feedback if the D.J. uses high headphone gain. Therefore, if the D.J. must use the air monitor, the headphone amplifier should be driven from the output of the Monitor Rolloff Filter (see above).

Such problems can be avoided if the D.J. phones are driven directly from the program line or, better, by an inexpensive compressor connected to the program line. (Most stations have such a compressor gathering dust in the back room.) If the D.J. relies principally on his phones to determine whether the station is on the air, simple loss-of-carrier and loss-of-audio alarms should be added to the system. Such alarms could be configured to cut off audio from the D.J. phones in the case of an audio or carrier failure.

(Those familiar with the old OPTIMOD-AM Model 9000A may have encountered a "comb-filtering" problem when headphones were driven from the air monitor. This comb filtering was due to the fact that the old OPTIMOD-AM contained delay lines which delayed the signal approximately 4 milliseconds. Acoustically mixing the delayed sound with the bone-conducted voice at the D.J.'s ear caused phase cancellations, resulting in an unnatural coloration of the D.J.'s voice. Your new OPTIMOD-AM Model 9100A does not have a delay line per-se, and only delays audio about 250 microseconds. Comb filtering should not be a problem.)

STUDIO/TRANSMITTER LINKS

To achieve the full audible benefit of OPTIMOD-AM processing, a 15kHz STL must be used. The loss of "air" and "definition" due to the restricted response of an 8kHz link will be clearly audible on the air.

If the STL has limited dynamic range, it may be desirable to compress the signal at the studio side of the STL. We recommend use of the Orban 422A (mono) or 424A (stereo) Compressor/Limiter/De-esser as a studio compressor. By adjusting the 422A/424A to produce slow attack and release times, it is possible to use it to perform the function of OPTIMOD-AM's internal Broadband AGC, while simultaneously protecting the STL. If this is done, the Broadband AGC should be defeated by positioning jumpers on Card #6. **Initialization Option 6** in **Part 3** contains instructions for doing this.

The output of OPTIMOD-AM is very tightly controlled with regard to overshoot, tilt, and ringing. In order to obtain maximum loudness, overshoot, tilt, and/or ringing must not be introduced by the link between OPTIMOD-AM and the transmitter. This means that if OPTIMOD-AM is mounted at the studio, it cannot be connected to the transmitter through a standard telephone line, since this will exhibit all of the aberrations listed above. For the same reason, no lowpass filter may be used between OPTIMOD-AM and the transmitter. (OPTIMOD-AM's internal lowpass filter renders any such external filter unnecessary.)

A composite STL possesses the requisite characteristics, and can be used to carry the output of the OPTIMOD-AM to the transmitter. However, the output of a typical composite STL receiver is at the wrong level and impedance to directly drive a typical transmitter (which requires +10dBm into 600 ohms in most cases). Therefore, the transmitter must almost certainly be modified to make it compatible with the STL. If this is done, no permission from the FCC is necessary. However, at the time of your next next license renewal, you are required to file a description of the modifications performed (see FCC Rules, sections 73.43, 73.44). Because use of a composite STL has so many ramifications, we recommend doing so only as a last resort, since installation of OPTIMOD-AM at the transmitter is vastly less complicated.

5kHz BANDWIDTH LIMITATION

Certain international standards (such as those of the EBU) require limiting transmitted audio bandwidth to 5kHz. This can be done by means of the 9100A's optional Card #1-F, which provides this limitation for mono units only. Card #1-F is fully described in its own manual.

If stereo operation is desired with 5kHz bandwidth limitation, the optional Card #1-S can provide this function (as well as several others, individually selectable). See the section on **AM Stereo** below.

TRANSMITTER PLANT CONSIDERATIONS

The behavior of an FM station is more or less determined by the behavior of the exciter. Alas, this is not true in AM! The performance of an AM station is highly dependent upon the high-power sections of the transmitter, and upon the behavior of the antenna system.

OPTIMOD-AM is not a cure-all. However, its transmitter equalizer can cure linear problems caused by the transmitter or antenna system. The transmitter equalizer cannot cure nonlinear problems, particularly those caused by inadequate power supplies, modulation transformers, or reactors. If any of these components saturate or otherwise fail to perform under heavy power demands, no amount of small-signal equalization will solve their problems.

The Transmitter: An AM transmitter is required to provide 150% of unmodulated carrier power when it is modulating 100%. This power must come from somewhere: this "somewhere" is the high voltage power supply. Such supplies are subject to two major problems:

1) Sag, which causes static carrier shift; and

2) Resonance, which causes dynamic carrier shift, or "bounce".

Sag is a result of inadequate steady-state regulation. It causes the carrier shift which is seen on your modulation monitor. The FCC legally limits it to -5%; this corresponds to about 0.5dB, which is not a terribly significant loudness loss.

A more serious problem is dynamic carrier shift, or "bounce". This has been known to cause up to 3 dB loudness loss. It is usually caused by resonances in the LC filter network in the power supply. Any LC network has a resonant frequency. In order to achieve reasonable efficiency, the power supply filter network must be underdamped. Therefore, this resonance is excited by high modulation, and can cause overmodulation on the low-voltage peaks of the resonance.

Curing bounce is not at all straightforward because of the requirement that the power supply filter smooth the DC sufficiently to meet the FCC's -45dB noise requirement. One approach that has been employed recently is use of a 12-phase power supply. Upon rectification, the ripple component of the DC is down about -40dB without filtering. Thus, a single-capacitor filter can be used, eliminating the filter inductor as a potential source of resonance with the capacitor.

Other sources of resonance include the modulation reactor and modulation transformer in conventional plate-modulated transmitters. Such transmitters will therefore not greatly benefit from a 12-phase power supply.

Recently, a new generation of transmitters employing switching modulation techniques has appeared. Such transmitters control "bounce" far better than do older designs. One would expect transmitters employing "outphasing" modulation schemes to also benefit substantially from a tighter power supply.

WARNING!

Some older transmitters were underdesigned by today's standards, because "modern audio processing" techniques to increase average modulation had not yet been developed and because the transmitters' designers assumed that average power demands on the modulator would be relatively small. If you have a transmitter designed before 1965, it should be carefully monitored to make sure that OPTIMOD-AM processing is not overheating the modulation transformer, the modulation reactor, or the power supply. The high frequency boost performed by OPTIMOD-AM can cause unusually high voltages in the final amplifier, which could cause arcing and/or component breakdown. (This latter problem has been found to be very rare, however). There is no hard-and-fast cure for such problems. They almost always require substantial modification of the transmitter with the addition of heavier-duty components and perhaps a whole new power supply for the modulator alone.

Slew-Induced Distortion: Much attention has been paid recently in the audio community to "Transient Intermodulation Distortion", or more correctly, "Slew-Induced Distortion" (SID) in feedback amplifiers. This distortion is caused by the amplifier-in-question's having a maximum available rate-of-change of its output waveform. It exhibits SID when musical waveforms try to force its output to change faster than this "slew rate limit".

The cause of this distortion is usually an open loop response which starts to roll off at a very low frequency. This rolloff is usually introduced after the input stage; thus the output of the input stage is forced by feedback to be highly preemphasized (to overcome the rolloff in the following stage). Because of this preemphasis, the input stage overloads easily. This input stage overload is the direct cause of SID.

It is not widely realized that certain AM transmitters are extremely prone to this type of distortion if they employ overall audio feedback around the transmitter (using rectified RF to supply the feedback signal). Because of the delays involved in the transmitter, it is necessary to roll off the open loop response at a very low frequency to make the feedback loop stable. This feedback improves the steady-state distortion measurements (SMPTE Intermodulation, and Total Harmonic Distortion). However, the conditions for severe SID still exist. Such distortion is highly offensive to the ear; it is a plausible explanation for why some transmitters may measure good, but sound bad.

Because the output of OPTIMOD-AM is highly preemphasized, it can cause severe audible distortion in a transmitter with considerable SID. SID is therefore of substantial concern in an OPTIMOD-AM installation.

SID can be detected with the CCIF Intermodulation Test. This involves introducing to the input of the system being evaluated a pair of high frequency tones closely spaced in frequency. The level of the difference frequency which results from passing these tones through said system is then measured.

Curing SID in a transmitter is not straightforward. The only way to do it is to reduce the amount of overall feedback employed, then to try to compensate for the decreased feedback by decreasing the amount of high frequency rolloff and, finally, to linearize the modulator stage-by-stage. THD and/or SMPTE IM may well become poorer as a result of this process. However, the transmitter will probably sound better.

CAUTION

MANY OF THE SUGGESTED PROCEDURES ABOVE INVOLVE MODIFICATIONS TO THE TRANSMITTER WHICH WILL NULLIFY ITS TYPE-ACCEPTANCE. BEFORE SUCH MODIFICATIONS ARE PERFORMED, THE ENGINEER SHOULD REFER TO PARTS 73.43 AND 73.44 OF THE FCC RULES REGARDING THE APPROPRIATE ADMINISTRATIVE PROCEDURES.

Incidental Phase Modulation: All of the AM stereo systems actually modulate the transmitter by providing an AM and PM component at the output of the AM stereo exciter. The AM output is connected directly to the transmitter's audio input; the PM output is the output of a modulated oscillator at carrier frequency which replaces the fixed-frequency oscillator within the transmitter. These AM and PM components are the result of processing within the exciter which assures that the radiated carrier has the characteristics specified by the appropriate AM stereo system.

If the transmitter creates incidental phase modulation during amplitude modulation, then stereo performance will suffer. Incidental PM has many potential causes, most of which are associated with excessively narrow bandwidth in the transmitter or antenna system. Thus widening the system bandwidth (which is important for AM stereo) will tend to have a favorable effect on incidental PM.

Incidental PM which is uncorrelated with the signal is usually in the form of hum and/or noise. This sort of noise is not detected on an AM radio or monitor with an envelope detector, but will be reproduced on a stereo radio, or on any radio with a synchronous detector (which is sensitive to both AM and PM components). Improved filtering of the power supply in the low-level stages of the transmitter may be required to reduce uncorrelated PM.

ASYMMETRY

The FCC permits positive peaks of up to 125% modulation. Many transmitters cannot achieve such modulation without substantial distortion, if at all. In such cases, the power supply can be beefed up. RF drive capability to the final power amplifier must sometimes be increased.

IT IS IMPORTANT NOT TO DRIVE THE TRANSMITTER BEYOND ITS LINEAR RANGE IN THE ATTEMPT TO ACHIEVE 125% POSITIVE MODULATION. THIS WILL NOT INCREASE LOUDNESS -- IT WILL ONLY ADD DISTORTION.

In addition, asymmetrical operation can increase distortion for two other reasons:

1) OPTIMOD-AM's input conditioning filter contains a phase scrambler which makes asymmetrical input material, like voice, substantially symmetrical. It is easily demonstrated that modulating symmetrically produces a considerably louder and cleaner sound than asymmetrical modulation which retains the natural asymmetry of the input program material.

   OPTIMOD-AM permits asymmetrical operation of both the safety clipper and multiband distortion-cancelled clipper to produce artificial asymmetry. This will slightly increase loudness and brightness over the symmetrical case, and will produce dense positive peaks up to 125% if this is desired. However, such asymmetrical processing by its very nature produces both odd and even-order harmonic and IM distortion; symmetrical processing produces only odd-order distortion. While even-order harmonic distortion may sound pleasingly bright, IM distortion of any order sounds nasty. Therefore, asymmetrical modulation must sound dirtier than symmetrical modulation unless you have carefully preserved any natural asymmetry in the input program. (Because of the phase scrambler and the nature of the crossover system employed in the 9100A's 6-band limiter, such asymmetry cannot be preserved by the 9100A.)

2) Some of the newer transmitters of the pulse-width modulation type contain circuitry to hold the carrier shift constant with modulation. Since artificial asymmetry can introduce short-term DC components (corresponding to dynamic upward carrier shift), the carrier shift cancellation circuitry in such transmitters can become confused, resulting in further distortion.

Asymmetrical operation in stereo is not recommended. This is because some of the distortion added by the asymmetrical processing will decode in a spatial location different than the voice or instrument being processed, making the added distortion more obvious psychoacoustically. The mechanism causing this phenomenon (which is not dissimilar to the distortion caused by composite clipping in FM stereo) is explained in **AM Stereo** below.

ANTENNA SYSTEM

An AM antenna system, whether directional or non-directional, frequently exhibits two problems. These are:

1) Inadequate bandwidth; and/or,
2) Asymmetrical impedance.

Often, a system will exhibit both problems simultaneously.

An antenna with inadequate bandwidth couples RF energy into space with less and less efficiency at higher sideband frequencies within the ±15kHz bandwidth of the assigned channel. Instead, it reflects these higher frequency sideband components back into the transmitter or dissipates them in the tuning networks. This not only results in dull sound on the air (and nullifies OPTIMOD-AM's principal advantage: its ability to create a highly preemphasized signal without undesirable side effects); it also wastes energy, can cause distortion, and can shorten the life of transmitter components.

Asymmetrical impedance is simply the common point impedance's not being symmetrical on either side of the carrier frequency. This problem can cause transmitter misbehavior and sideband asymmetry, resulting in on-air distortion where envelope detectors are used in receivers (as they universally are as this manual is written).

Neither problem is capable of easy solution. In most cases, unless the Chief Engineer is a knowledgeable antenna specialist, a reputable outside consultant should be employed to design correction networks for the system.

It should be noted that many antenna systems are perfectly adequate. However, if the transmitter sounds significantly brighter and/or cleaner into a dummy load than it does into your antenna, the antenna system should be evaluated and corrected if necessary.

The requirements for AM stereo are substantially more rigorous than those for mono operation; the antenna must be wideband and symmetrical if AM stereo broadcasting is to be successfully implemented!

THE OPTIMOD-AM TRANSMITTER EQUALIZER

As discussed in **Transmitter Equalizer And Output Amplifier** in the **Simplified System Description** in **Part 1**, OPTIMOD-AM is equipped with a transmitter equalizer which can pre-compensate (within limits) for tilt, overshoot, and ringing in transmitter/antenna systems.

There are four separate and independent groups of Transmitter Equalizer controls available. Which group is activated is determined by the status of logic within the 9100A. This logic can be switched (either by means of front-panel momentary switches or by remote control pulses) into one of four modes: DAY/TX1, DAY/TX2, NIGHT/TX1, and NIGHT/TX2. While these four combinations' names suggest their most-used applications, nothing says that you must switch transmitters and/or patterns according to the names that we have given the four groups of controls. No group of controls is essentially different from any other group: each group is "general purpose" and is there to "tune" the Transmitter Equalizer to meet the needs of your particular installation. You need not use or adjust all four groups.

It is important to understand that both TX1 and TX2 outputs are active at all times, regardless of the status of the TX1/TX2 switching logic. In addition, the TX EQ mode chosen at any one time affects both outputs (i.e., the TX1 and TX2 outputs can never have separate TX EQ's simultaneously applied to them.) This never causes a conflict because we can imagine no instance where TX1 and TX2 would be on the air simultaneously.

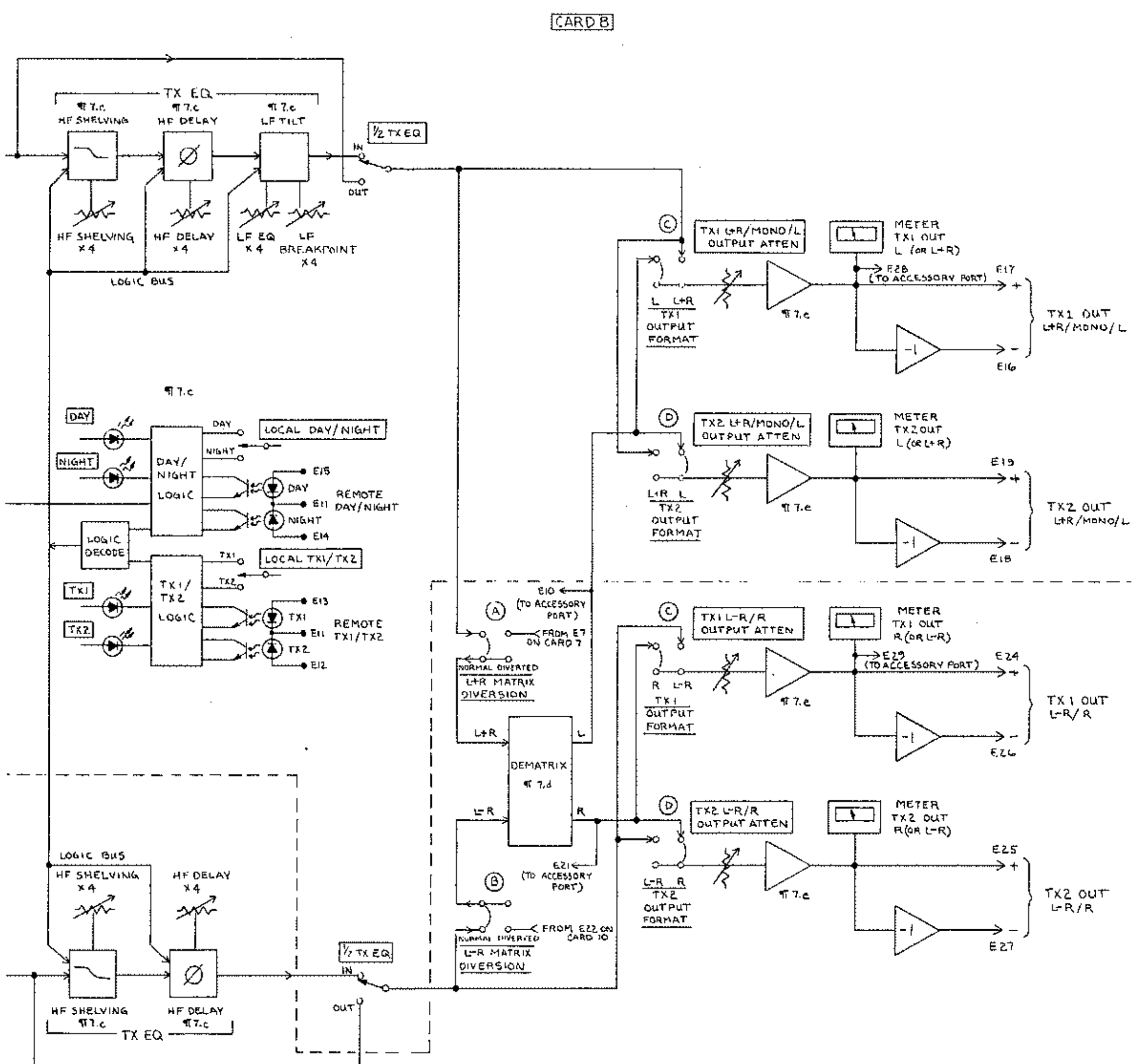


Fig. 2-2: Functional Block Diagram of TX EQ And TX Program Amplifiers

Application Examples: On powerup, the system comes up in the DAY/TX1 mode. If you have only one transmitter requiring correction, then you may need to adjust only the DAY/TX1 group. Or, if you have a modern main transmitter with accurate pulse response which does not require correction, you can turn all controls in the DAY/TX1 group fully counterclockwise, defeating any correction. You can then adjust the DAY/TX2 group to correct an older, standby transmitter which does require correction.

If you have an antenna which introduces overshoot and ringing into the RF envelope, and its behavior varies according to pattern, it may be necessary to use all four groups of controls to accomodate all of the variations.

MODULATION MONITOR AND RF AMPLIFIER

Field experience has shown that many AM modulation monitors (particularly those of older design) indicate dynamic modulation inaccurately, although they may indicate sine wave modulation correctly. This occurs when the audio filter after the demodulator diode is not phase-linear, and exhibits overshoot and ringing. An incorrectly designed modulation monitor may indicate modulation as much as 3 dB higher than that actually occurring.

In addition, highly selective RF amplifiers have been known to suffer from similar problems. They can overshoot and ring if the passband filters are too sharp, thus causing the monitor to falsely indicate high modulation.

If your modulation monitor is not in agreement with an oscilloscope monitoring the RF envelope at the common point, do not assume that the monitor is indicating fast peaks that your eye cannot see. A more probable cause of the disparity is overshoot in the monitor or RF amplifier. If this problem is observed, we recommend that you replace your monitor with one of state-of-the-art design.

Note also that modulation percentages will vary in different parts of the radiated field of a directional antenna system. Depending on the location observed, actual modulation can be either lower or higher than modulation observed at the common point.

POWER FAILURES

After a power failure, bear in mind that the transmitter equalizer mode-control logic will come up in DAY and TX1 modes, unless the power interruption was less than one second or so. In this case, the powerup circuitry may not have sufficient time to reset, and an unexpected mode may be entered. Part of any restart procedure after a power failure should include resetting the OPTIMOD-AM logic as appropriate.

AM STEREO

This section on AM stereo was written with the assumption that the reader is already generally familiar with the OPTIMOD-AM system and its components. It discusses those aspects of OPTIMOD-AM installation, adjustment, and operation relevant to AM stereo.

Comments herein were developed in early 1985 using the best information available at that time.

The FCC (U.S.A.) has approved a "marketplace selection" of AM stereo systems. Any of several systems may be used; it is assumed that marketplace forces will cause a single system to prevail. As of this writing (March 1985), the Belar, Harris, and Magnavox systems have become extinct; Kahn and Motorola are the only remaining contenders.

AM stereo, with or without OPTIMOD-AM, is an inherently tricky proposition and will not, in any station, be successful without a considerable amount of real engineering input. It is by no means as easy as FM stereo!

There are serious potential limitations involving the station's transmitter and antenna. There is a current (in 1985) lack of precise information as to the characteristics of the exciters for certain systems. Different systems have varying amounts of sensitivity to certain processing parameters.

It appears that AM stereo can be made to work reasonably well with careful engineering. Where the basic transmission system works well, OPTIMOD-AM will effectively enhance loudness, brightness, and coverage with an unusual lack of undesirable side-effects. Where AM stereo is not working well due to incomplete engineering or weaknesses in the basic transmission system, OPTIMOD-AM will not cure the problems and may, in some cases, exaggerate them.

We hope that OPTIMOD-AM will not be blamed by reflex for the inevitable problems that will occur in many installations. We will help as best we can, but installation of OPTIMOD-AM into a stereo environment should not be expected to be automatically successful without appropriate field engineering input from a well-qualified engineer, consultant, or exciter factory engineer.

In all systems, the envelope modulation is forced to a close facsimile of the sum of the L and R channels to assure compatibility with mono radios having envelope detectors. To assure minimum loudness loss compared to monophonic transmission, it is necessary to process stereo audio in the "sum-and-difference" mode. This means that the L and R audio are passed through matrix circuits to create L+R (sum) and L-R (difference) signals. These signals are then passed separately through those parts of the processing which control modulation.

The 9100A/2 is equipped with the necessary matrix and dematrix circuits to process stereo audio in the "sum-and-difference" mode, making OPTIMOD-AM compatible, in that respect, with all the various AM stereo systems.

Preserving separation through such a system requires close matching and tracking of L+R and L-R (sum and difference) channels. For this reason, only the processing elements essential to the control of modulation handle the signal in sum-and-difference form. These elements are the six-band limiter, the multiband distortion-cancelled clipper, the safety clipper, the lowpass filters, and the transmitter equalizer. Each section is built with the highest precision to avoid a multiplicity of adjustments and to ensure field interchangeability of cards.

The input filter, broadband AGC, and receiver equalizer (preemphasis) handle the signal in conventional L and R form; the matrix creating the L+R and L-R is located between the receiver equalizer and the crossover filters for the multiband limiter.

Virtually all setup controls are located before the matrix. Mismatches between the settings of corresponding controls in the L and R channels will thus affect channel balance, but not separation (as they would were they included within the sum-and-difference processing).

The mono OPTIMOD-AM 9100A/1 can be converted to a stereo 9100A/2 by plugging in three circuit cards and other minor work. In addition, the optional #1-S Stereo Enhancement Card may be desired (or required; see below). The chassis is fully wired for stereo, and the unit is equipped with stereo VCA's which have been pre-aligned for correct channel balance and tracking, thus facilitating stereo conversion with minimum fuss. **Appendix G** contains instructions on converting from mono to stereo or vice-versa.

THE #1-S STEREO ENHANCEMENT CARD

Card #1-S for the 9100A is an optional card which plugs into slot #1 of the OPTIMOD-AM mainframe. It exists primarily to provide special processing for the various AM stereo systems. It offers three functions which can be used in any combination as needed:

1. Single-Channel Modulation Limiter And Stereo Enhancer
2. 5kHz Lowpass Filter (Stereo)
3. 200Hz L-R Highpass Filter (and phase-matching L+R allpass filter).

The card is always required for the Motorola system, and is optional (but possibly advantageous) for the Kahn system.

Application of Card #1-S

There are three "subsystems" on the card. Each will be discussed in turn.

1. **Single-Channel Limiter/Stereo Enhancer Subsystem:** This subsystem provides a -75% negative peak modulation limit on the L and R channels.

   In addition, a STEREO ENHANCE feature (controlled by a trimmer on the front of the card) can increase the level of the L-R (stereo difference channel) by up to 6dB with reference to the L+R (stereo sum channel). Enhancement is activated by advancing the trimmer CW. This can substantially increase stereo loudness and apparent stereo separation. When a large amount of enhancement is used, distortion is automatically prevented by the single-channel limiter system, which reduces the L-R gain dynamically as necessary to avoid excessive energy in the L-R channel. However, a large amount of enhancement can sometimes increase apparent reverberation or introduce other changes in musical balance. Enhancement should therefore be used with discretion.

   Use of the single-channel modulation limiter is:

   -- Required in Motorola installations to prevent the "distortion corrector" on the Motorola decoder chip from clipping. Use of the stereo enhancer feature is optional.

   -- Not recommended in Kahn installations. Use of the stereo enhancer feature is optional with the STR-84 exciter, and not recommended with the STR-77 exciter.

2. **5kHz Filter Subsystem:** This subsystem, which is provided primarily for foreign and international broadcasters and for others who wish to limit interference to first-adjacencies at night, consists of two matched 5kHz phase-corrected lowpass filters in the L+R and L-R channels. (Other frequencies are available on special order.) Electronic switches are provided to enable or defeat the filters. When they are defeated, overall 12kHz bandwidth limitation is provided by other filters external to Card #1-S.

   The filters can be operated in one of three modes:

   1. 12kHz at all times (as shipped);
   2. 5kHz at all times;
   3. 12kHz DAY/5kHz NIGHT, controlled by the the mainframe's DAY/NIGHT logic.

   If a mono lowpass filter (usually 5kHz) is the only requirement, as is typical in foreign and international broadcasting, then the less expensive Card #1-F may be used instead of Card #1-S. That card contains only one lowpass filter with the same logic switching as the 5kHz Lowpass Filter subsystem on Card #1-S.

   Note, however, that Card #1-S is usable with mono OPTIMOD-AM's, provided that the Single-Channel Limiter and/or 200Hz Filter are not used and are jumpered out according to the instructions provided in **Appendix I** of this manual under **Adjustment And Jumper Strapping.**

3. **200Hz Highpass Filter:** The 200Hz L-R Highpass Filter function is required only if you are using low-frequency SCA or telemetry in the below-200Hz frequency band of the L-R channel. The pilot tones of all systems are adequately protected by the 50Hz input highpass filters supplied standard in the OPTIMOD-AM system.

   Note particularly that these filters are not required for conventional AM telemetry in which transmitter status readings are returned to the studio by means of low-level, low-frequency amplitude modulation of the RF envelope.

   Use of the 200Hz L-R Highpass Filter will cause a degradation in the low-frequency dynamic separation performance of the processing system, and should therefore be used only if necessary. Undesired artifacts can be particularly noticeable under single-channel modulation conditions. This occurs because, under single-channel conditions, the L+R and L-R channels are normally identical and produce identical amounts of clipping distortion in the L+R and L-R clippers. If the 200Hz filter is inserted, it makes the L+R and L-R channels non-identical. Non-identical clipping distortion is therefore produced in the L+R and L-R clippers. Upon dematrixing into L and R, some of the clipping distortion does not cancel in the matrix and appears instead in the opposite channel from the desired program material. Psychoacoustically, this spatial separation of the distortion from its generating program material may increase the obviousness of such distortion, particularly on headphones. (Program material with typical soundfields will not tend to cause a problem, since most records contain little stereo information below 200Hz. Thus the 200Hz filter will have little effect.)

The Kahn System And The Accessory Port

Use of OPTIMOD-AM with the Kahn system in an optimum way requires a special interconnection scheme, and possibly minor modifications to OPTIMOD-AM depending on the vintage of the Kahn exciter.

If OPTIMOD-AM is operated with the Kahn STR-77 exciter (the first-generation Kahn exciter), it is advisable (but not mandatory) to use OPTIMOD-AM's "Accessory Port" to break the OPTIMOD-AM L+R signal path just before the safety clipper in order to use the OPTIMOD-AM safety clipper to control peaks.

The Kahn exciter's envelope output (ordinarily connected to the audio input of the transmitter) is instead returned to the OPTIMOD-AM Accesory Port so that it can be clipped by the OPTIMOD-AM's L+R safety clipper before being applied to the transmitter. The safety clipper then determines peak levels after the exciter's L+R phase-shift networks, tightly controlling envelope modulation.

It is not feasible to break the signal path within the exciter to similarly process the PM component. However, the exciter contains internal clipping to prevent PM overdeviation.

The STR-77 Kahn exciter does not function ideally with the 9100A/2's Card #1-S because this card must be operated with its L+R clippers (CR1, CR2) and L-R clippers (CR12, CR13) functional in order to present realistic peak levels to comparators IC6 and IC9. (These comparators control excessive L-R levels by firing whenever the single-channel levels produced by the matrixing of L-R with L+R exceed 75% negative modulation.) In the STR-77 Kahn exciter, the clipped L+R and L-R must be applied to the Kahn exciter's 90 degree phase difference networks. These distort the peak level of the audio waveform, requiring another stage of clipping after the phase-difference networks. Thus the L+R and L-R clippers on Card #1-S introduce clipping distortion without contributing to modulation control. This added distortion can force you to turn down OPTIMOD-AM's CLIPPING control, causing a loss of loudness.

The second-generation Kahn exciter (Model STR-84) is much improved, and contains a loop-through facility which allows you to place the phase difference networks before most of the OPTIMOD-AM processing. If this is done, the L+R and L-R clippers on Card #1-S can work properly to control modulation levels. If this is not done, distortion and/or loudness penalties will be paid as in the case of the first-generation exciter.

The STR-84 Kahn exciter breaks its signal flow after the phase-difference networks and provides L+R and L-R inputs and outputs to incorporate audio processing. The best location for the phase difference networks is between the OPTIMOD-AM Program Equalizer and Six-Band Limiter. Accessing this point requires some rewiring of the OPTIMOD-AM Accessory Port.

Appendix I of this manual presents detailed instructions for interfacing both the STR-77 and STR-84 exciters to OPTIMOD-AM.

Preemphasis And AM Stereo

Both Motorola and Kahn are non-linear systems. Non-linear systems can create distortion on limited-bandwidth mono or stereo receivers when a substantial amount of high frequency boost is employed in the processing. This is because these systems work by introducing predistortion frequency components into the signal in order to provide distortion-free demodulation of the L+R signal on a conventional envelope detector, provided that the receiver has an infinite bandwidth. When part of the signal is filtered out (as in a conventional IF filter in a real-world receiver), distortion cancellation can no longer occur accurately because some of the frequency components which restore the envelope have been removed. Particularly noticeable problems may occur on vocal sibilance and other such material which contains mostly high frequency energy. (Sibilance will typically be boosted to a very dense 100% modulation by 9100A processing). The radio will filter the undistorted high frequency energy out, leaving primarily predistortion components which sound like difference-frequency IM distortion. Audibly, the sibilance can "splatter" and may sound more like "ffff" than "ssss".

The Kahn system minimizes such potential problems by lowpass-filtering the L-R at 5kHz (STR-77 exciter) or 7.5kHz (STR-84 exciter), and broadcasting frequencies above this cutoff frequency in mono. While the 5kHz filter in the STR-77 seems effective in eliminating any sibilance distortion, there might be a problem with the higher 7.5kHz cutoff in the STR-84 because sibilance energy is concentrated at 6kHz and will therefore be passed by the 7.5kHz filter. (This is conjecture; we have had no experience with the STR-84 exciter's behavior with preemphasis since this exciter has been type-accepted in the U.S.A. for only a few months as this is written.)

Motorola exciters (which provide separation to 15kHz) require use of Card #1-S to control potential distortion and occupied bandwidth problems when preemphasis is used. As first discussed above, this card contains a "single-channel limiter" circuit which limits negative modulation in the Left and Right channels to -75% by means of Left and Right asymmetrical clippers. Excessive clipping distortion is prevented by a limiter which applies gain reduction to the L-R channel prior to the clippers, producing a dynamically-variable blending of the Left and Right channels. This controls how hard the asymmetrical clippers are driven and thus avoids distortion.

Because this circuit operates on preemphasized audio, it has a bonus benefit: High-energy high-frequency L-R program material (like off-center sibilance) is boosted by preemphasis and thus tends to activate the variable-blend circuit, controlling excessive HF L-R modulation. In essence, the variable-blend circuit acts as a fast-attack/fast-release "de-esser" for the L-R channel only, automatically preventing excessive occupied bandwidth and distortion on narrowband mono radios.

Since the L-R limiter operates only when necessary, full separation over the full broadcast bandwidth is produced with most program material. Because this system creates gain reduction in the L-R channel only, mono reception is unaffected and full mono quality is retained at all times.

Other expedients you can use to avoid distortion and occupied-bandwidth problems are as follows: First, announcers can be placed strictly center-channel. This will automatically keep sibilance out of the L-R channel (although recorded vocals will not be controllable).

Second, a de-esser such as the Orban 526A may be used on any announcer placed off-center. This is particularly useful if the announcer tends to have excessive sibilance or if an announce microphone with a "presence peak" is employed.

Third (and last), the amount of HF boost may be reduced. This, of course, will result in a duller sound on conventional narrowband radios, partially negating the advantage of OPTIMOD-AM. (If the steps above are followed, reduction of preemphasis should not be necessary.)

Stereo Transmitter Equalization

Full low- and high-frequency transmitter equalization is provided in the sum channel only. (This represents that part of the stereo signal handled by the transmitter's existing AM modulator.) The low-frequency equalizer is omitted from the difference channel because it was assumed that any AM stereo exciter will provide adequately extended low frequency response in its difference channel. Thus, correct adjustment of the low frequency equalizer in the sum channel will extend the effective low frequency response of the AM modulator section of the transmitter, improving low frequency separation because of better phase and amplitude matching between the sum and difference signal paths.

However, the high-frequency (shelving and delay) equalizers are often adjusted to add delay and to slightly roll off high frequencies in the sum channel in order to control overshoot caused by the transmitter and antenna system. To assure best separation, this rolloff and added delay must be precisely matched in the L-R channel. The L-R channel is thus equipped with shelving and delay equalizers identical to those in the L+R channel. Systems which insert phase shift into either the sum or difference channels (as discussed immediately above) may not be usable with the 9100A/2's transmitter equalizer. The exciter for such a system will ordinarily be equipped with its own transmitter equalizer, assuring that any type-accepted combination of exciter and transmitter can meet the FCC separation requirements.

The transmitter equalizer can be used in a special way in Kahn installations. (See **Appendix I.**)

Stereo And Asymmetry

In addition to the reasons discussed elsewhere in this **Part,** stereo introduces another reason not to use asymmetrical processing: Asymmetrical processing will introduce asymmetrical, distorted crosstalk from Right into Left (but not from Left into Right).

This is a direct result of sum-and-difference processing. Consider the case of pure L signal. It will pass through the L+R (sum) and L-R (difference) channels in-phase: both channels contain +L. Thus, any asymmetrical clipping will be applied equally to both sum and difference channels. Upon rematrixing into L and R, since the outputs of the sum and difference channels are identical, full cancellation of L will occur in the matrix, and no significant crosstalk into R will occur.

On the other hand, R passes through the difference channel as -R. Asymmetrical processing will affect the difference channel differently than the sum channel (because the R waveform is "upside down" in the difference channel). Therefore, upon dematrixing, the now non-identical waveforms will not cancel correctly, and crosstalk -- pure distortion! -- will appear in the L output.

This problem can be totally eliminated simply by operating symmetrically. In addition, all of the other audible advantages mentioned in the **Asymmetry** section will be obtained.

To Summarize

The Belar, Harris, and Magnavox systems are now considered to be extinct and have not been discussed in this edition of the manual.

The Motorola (C-QUAM) system requires use of Card #1-S to control potential receiver distortion and, if substantial preemphasis is used, to control occupied bandwidth.

Harris STX-1 and STX-1A exciters can be converted to produce C-QUAM transmissions. (The converted exciter is called the "STX-1B".) Harris can provide information on how to interface audio processing with the STX-1B exciter. Our #1-S Card is required.

Kahn exciters require some means of controlling peak envelope modulation after the phase shift networks in the exciter. This may require use of OPTIMOD-AM's Accessory Port to insert the OPTIMOD-AM safety clippers between the transmitter input and the AM output of the exciter. Alternately (though less desirably) the OPTIMOD-AM safety clippers may be defeated and the peak limiting function provided within the exciter may be used instead. **Appendix I** of this manual provides more information.

We expect that the information in this section of the Manual will become outdated, and we will issue Field Engineering Bulletins as necessary to provide updates on the situation. Inquire if and when you are ready to install AM stereo.

Part 3: Installation

If you have not already done so, please fill out the Registration Card fully and mail it to the factory. (See **Preface.**)

IMPORTANT

OPTIMOD-AM is a major technological breakthrough in audio processing. It enables you to obtain a level of audio quality on AM that has heretofore been thought to be impossible. It fully exploits the limits of the standard AM channel. Its full capability may even exceed the limits of some AM transmitters and/or antennas.

Because OPTIMOD-AM is a much more powerful and complex processor than anything that has yet appeared on the market, it is important to:

MAKE NO ASSUMPTIONS!

FAMILIARIZE YOURSELF WITH THE FIRST FIVE SECTIONS OF THIS MANUAL BEFORE PUTTING YOUR OPTIMOD-AM ON THE AIR!

UNPACKING AND INITIAL INSPECTION

You are now ready to proceed with unpacking and installation of your OPTIMOD-AM.

Sometime during the life of your OPTIMOD-AM, you may wish to re-ship or return it. Since it is expensive and heavy, it is advisable to ship it only in the original packing materials which have been carefully designed to protect it. For this reason, it is wise to mentally note the method of packing and to <u>save all packing</u> materials.

Sage advice for repacking and reshipping your unit is contained at the end of **Appendix F.**

Various items are packed with OPTIMOD-AM:

(1) Line Cord
(4) 10-32x3/4" Rack Screws
(1) 3-wire AC Adapter
(1) Operating Manual
(1) 5/64" Allen Wrench (for front panel screws)
(1) RCA Phono Plug (to access TP1 for TX EQ adjustments)
(2) Keys For Adjustment Door
(4) 620 ohm ±5% 1/2 watt carbon film resistors (for input and output termination if required)
(1 or 2) Monitor Rolloff Filter(s) [as required for mono or stereo]
(1) Extender Card

PHYSICAL EXAMINATION

Perform a general inspection of the perimeter of the unit to check for obvious damage.

DAMAGE CLAIMS MUST BE MADE BY YOU AGAINST THE CARRIER IMMEDIATELY UPON DISCOVERY. Save packing and other evidence of damage for the carrier's inspector.

To inspect the interior, set the unit on a flat, soft surface. Remove the three hex-socket screws at the top of the front panel using the wrench provided. The front panel, which is hinged at the bottom, will then tilt downward and reveal the interior. Look for IC's or other loose parts which may have fallen out during shipment.

Remove the subpanel through which the controls protrude by gently twisting the four DZUS fasteners 1/4 turn counterclockwise. Tilt the panel to remove it. This reveals the "card cage".

Various components are mounted in sockets for servicing convenience. It is possible that a component could have been dislodged by heavy shocks in shipment.

Starting at the left, using the card ejector tabs, carefully remove each card in turn, examine it, and replace it. Make sure that all components are properly seated in their sockets. Check with particular care to make sure that none of the IC's are held in their sockets by one row of leads only.

To permit performing the initialization procedures described later in this **Part,** leave the panel open.

ENVIRONMENT

OPTIMOD-AM is ordinarily located reasonably close to the main transmitter or phase-linear STL transmitter. The chassis requires 4 units (7"/17.8cm) in a standard 19" rack.

Good monitoring loudspeaker systems seem rare at transmitter sites. However, such a system which can be easily heard from the location in which OPTIMOD-AM is mounted will facilitate subjective adjustments.

Where humidity is typically high, the environment should be controlled to prevent moisture from condensing on circuit cards of all plant equipment, including OPTIMOD-AM, as this can degrade performance. Using some of the exhaust from the transmitter to heat the building slightly above ambient temperature is often sufficient to prevent problems.

Please remember that the reliability of any electronic equipment is enhanced by maintaining moderate operating temperatures. OPTIMOD-AM should never be operated in ambient above 50 degrees C (122 degrees F).

If electrical storms are frequent, it may be advisable to add suitable Varistors or other protection between each incoming wire (AC, remote control, and audio) and a solid earth ground as indicated by local experience.

OPTIMOD-AM has been carefully designed to operate in high-energy EMI environments and no special placement precautions need be observed unless RFI is encountered in operation.

If possible, OPTIMOD-AM should be mounted in a location away from vibration such as that caused by large blowers.

POWER CONSIDERATIONS

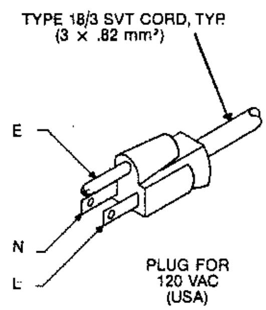
OPTIMOD-AM will operate on 115/230V ±15% 50-60Hz AC power. Due to the conservative design of the power supply, it should also operate properly on 100 volt and on 208 volt service.

Without applying power to the line cord, turn the power switch ON and check the position of the LINE VOLTAGE SELECTOR switch. All units are shipped with this switch in the "115 Volt" position. Adjust the selector switch so that the appropriate voltage is indicated. Check the fuse, and replace with the following values if necessary:

100/115 VOLT: 1/2 amp SLO-BLO, 3AG-type (as supplied);
208/230 VOLT: 1/4 amp SLO-BLO, 3AG-type.

AC connection to the chassis is made through an RF filter with IEC-standard mains connector. This filter is designed to meet the standards of all international electrical safety authorities, and leaks less than 0.5mA to the chassis when operated from 230V mains, and less than 0.25mA when operated from 115V mains.

A U.S.A.-standard "U-ground" power cord is supplied to connect to the IEC socket. Users in other countries should be able to obtain a power cord compatible with their country's standard. If you choose to cut the "U-Ground" plug from the cord and replace it with a plug appropriate to your standards, refer to Fig. 3-1 below.



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

Fig. 3-1: **AC MAINS CORD DETAIL**

MOUNTING AND GROUNDING

As a matter of good engineering practice, it is desirable that the OPTIMOD-AM chassis be properly connected to a good earth ground. Wire is totally ineffective at VHF and above; the best way to ground the OPTIMOD-AM chassis is to mount it solidly in a well-grounded rack (or the transmitter cabinet). The rack or cabinet must be connected to earth through a wide, thin copper ground strap.

To assure good electrical contact between the OPTIMOD-AM chassis and the rack, it may be necessary to scrape the paint from the rack and/or the OPTIMOD-AM mounting flanges. Measure the resistance between the OPTIMOD-AM chassis and rack, and verify that it is less than 0.5 ohm.

INPUT SIGNAL CONNECTIONS

Mono Operation: If you have a 9100A/1, use the LEFT input. If you have purchased a 9100A/2 in anticipation of future stereo operation, but are presently operating in mono, see the discussion below in **Mono Operation of Stereo Units.**

In a high RF field, the audio input to OPTIMOD-AM must be fully-balanced, and should be run in 100% foil-shielded cable like Belden 8451. The shield should be connected to earth (chassis) ground at both ends. In addition, you should make sure that the telephone line termination box or STL receiver is properly grounded to earth.

In low-RF environments, the shield should be grounded at one end only. Audio may be run balanced for long distances, or unbalanced over distances of less than 20 feet (6m). OPTIMOD-AM should be operated with its integral 20dB input pad for levels between -10 and +10dBm, and without the pad for levels between -30 and -10dBm. Instructions for restrapping the pads are found below in **Initialization Option 1.**

The OPTIMOD-AM input is balanced bridging, and its impedance is 200K with the 20dB pad defeated and 11.2K with the 20dB pad operative. If the source requires a 600 ohm termination (such as a telephone line), connect a 620 ohm ±5% 1/2 watt carbon film resistor across each audio input. Such resistors are provided for your convenience.

In stereo installations, it is important that both left and right audio inputs be in phase. This is ordinarily assured simply by connecting the colored wires within all shielded cables symmetrically and consistently when wiring the two stereo channels. If a phasing error occurs, it will be indicated in on-air testing by the stereo monitor's indicating more L-R than L+R level.

NOTE

IF HIGH FREQUENCY FEEDBACK IS ENCOUNTERED WHEN OPTIMOD-AM IS PUT ON THE AIR, THIS IS PROBABLY DUE TO RF RECTIFICATION OCCURRING BEFORE THE OPTIMOD-AM INPUT. BECAUSE OF OPTIMOD-AM'S EXTREMELY HIGH GAIN AT HIGH FREQUENCIES, FEEDBACK CAN OCCUR EVEN IF RF RECTIFICATION IS SLIGHT. A 0.01 uF CAPACITOR ACROSS THE OPTIMOD-AM INPUT LINE(S) CAN OFTEN CURE THIS PROBLEM.

Auxiliary Input: The Auxiliary Input is a balanced bridging input with an absolute overload point of +21dBm. It applies a slight high frequency boost of 2.1dB, starting at approximately 2kHz. Its low frequency response is flat to below 10Hz.

With the AUX INPUT ATTEN control fully CCW, an input of +12dBm @100Hz is required to produce clipping in the 9100A's safety clipper. With the AUX INPUT ATTEN control fully CW, -14dBm will produce the same effect.

If the Auxiliary Input is used for program material, a peak limiter with a compression ratio in excess of 20:1 should be used before this input to protect against excessive clipping in the 9100A's safety clipper, since the only peak level control following the Auxiliary Input is the safety clipper. If a limiter with built-in clipping is employed, it is recommended that the built-in clipping be defeated so that the 9100A's safety clipper can serve that purpose, avoiding double-clipping.

The rationale for the Auxiliary Input is discussed in **Various Application Notes (Part 2).**

AUDIO OUTPUT The outputs of OPTIMOD-AM are transformerless and balanced. Drive capability is +20dBm into 600 ohms, which is the lowest permitted load impedance.

DO NOT GROUND EITHER SIDE OF THE OUTPUT.

If an unbalanced output is required, it should be taken from either output to circuit ground.

If a stereo OPTIMOD-AM is used in mono service, see the discussion below in **Mono Operation of Stereo Units.**

When the output is strapped for L+R/L-R, a positive-going signal at the (+) output terminal corresponds to positive modulation. When the output is strapped for L/R, an inverting matrix is added into the signal path. Therefore a negative-going signal at the (+) output terminal corresponds to positive modulation.

In installations where OPTIMOD-AM is installed at the transmitter, the output should be connected to the transmitter through two-conductor shielded cable with the shield grounded at one end only.

Before installation, we advise disconnecting the output cable from the OPTIMOD-AM, driving it with a good square wave generator (with low impedance output), and checking waveforms at the input stage of the transmitter modulator to make sure that overshoot and/or ringing have not been introduced by the transmitter's input transformer and/or by resonance between the input transformer and the capacitance of the input cable. If such problems are observed, it is sometimes possible to minimize them by placing a 300 ohm 5% 1/4 watt carbon resistor in series with each side of the input line to the transmitter. This may damp out ringing. In other cases, the transmitter's input transformer may have been chosen without regard for its transient response (particularly with older transmitters designed before the advent of "modern audio processing"), and the input transformer may have to be replaced with a better transformer or with an electronic differential amplifier.

This may seem fussy; however, EVERY dB OF OVERSHOOT IS A dB OF LOUDNESS LOST!

IMPORTANT

UNDER NO CIRCUMSTANCES SHOULD ADDITIONAL CLIPPING DEVICES, SUCH AS THE RCA "POWERMAX" OR THE HARRIS "MODULATION ENHANCER" BE EMPLOYED AFTER OPTIMOD-AM! THE ADDITIONAL DISTORTION INTRODUCED BY THESE DEVICES WILL TOTALLY NULLIFY THE ADVANTAGES OF OPTIMOD-AM's DISTORTION-CANCELLING CLIPPER!

MONO OPERATION OF STEREO UNITS If you have purchased a stereo OPTIMOD-AM in anticipation of future stereo operation but are presently operating in mono, the easiest way to assure proper mono operation without having to move initialization jumpers from their standard factory-installed stereo configuration is as follows:

a) Connect the audio input line to both LEFT and RIGHT OPTIMOD-AM inputs in parallel, thus driving both L and R Broadband AGC's and assuring proper operation of their control loop. (If a stereo STL is already in place, the inputs of the two STL transmitters can be driven in parallel, provided that the two STL's are phase-matched within 20 degrees, 50-12,000Hz.)

b) Duplicate any adjustments made to the setup controls of the "Left" (Card #4) side on the "Right" (Card #5) side. Satisfactory accuracy is achieved by matching the controls on the basis of panel calibrations.

c) Use the TX1 (and also, if you need it, the TX2) L OR L+R output(s) to drive your transmitter(s).

d) Remove Card #10 from its slot. This breaks the L-R signal path within OPTIMOD-AM and assures that correctly peak-controlled mono audio will be present at the L OR L+R outputs regardless of whether the output cards are strapped for L/R or L+R/L-R operation.

(**NOTE:** If you choose to leave the #10 Card in place, the output cards should be strapped for L+R/L-R operation to assure accurate peak level control from the L OR L+R output. See **Initialization Options** below.)

REMOTE CONTROL

Five terminals for remote control of DAY/NIGHT and TX1/TX2 status are located on the rear-panel barrier strip. Switching can be effected by applying a pulse of 6-24V AC/DC between the appropriate terminal and "Common". If DC is used, connect the "+" polarity to the "Day" or "Night" terminal, and the "-" to "Common".

If you wish to use 48V, current limiting should be provided by connecting a 1K 2W $\pm$10% carbon composition resistor in series with the "Common" terminal.

Local control of DAY/NIGHT and TX1/TX2 status is provided by means of momentary front-panel switches.

INITIALIZATION OPTIONS

OPTIMOD-AM is a versatile system that can be set up in a variety of ways and which can be used for mono or stereo. To ensure universal compatibility, we have provided a number of initialization options which are selected by moving jumpers on the circuit cards. There are a total of 8 jumper positions in the mono unit and 16 in the stereo unit. Another 5 jumper positions are found on the optional Card #1-S (ordinarily used only in stereo units). Card #1-S jumpers are discussed in **Appendix** H of this manual.

It may be that your system will operate correctly with OPTIMOD-AM in its "as-shipped" condition. However, you should still consider each of the options below to determine if the "as-shipped" condition is correct for you.

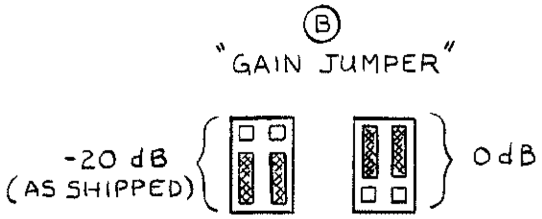
As you consider each of the following options note, by circling the appropriate image in pencil, which options have been taken and which left in the "as-shipped" condition. This will be valuable as a reference for you or your successors, eliminating the need to disassemble the unit to check on jumper positions.

We recommend that you consider all the options and mark the images appropriately before beginning work. If you decide that any jumpers must be moved from their "as-shipped" positions, gain access to the circuit cards by following the instructions provided in **Appendix C (User Access).** (If you have followed the instructions in **Unpacking and Initial Inspection,** above, the cards are already available for extraction as necessary.)

(The diagrams directly correspond to the physical appearance of the card when it is held such that its edge connector is to the left and its extractor tab at the top right.)

Option 1: Input Attenuator (Cards #4 and #5): The input is normally shipped with a 20dB pad, making the input suitable for levels between -10 and +10dBm. If the equipment driving OPTIMOD-AM is incapable of this level (such as a long equalized phone line), then you may bypass the pads to provide an additional gain of 20dB.

This is done by placing two jumpers on Cards #4 and #5 (stereo only) in the "0dB" position. These jumpers are marked "B".



The other jumper (marked "A") on these cards is used to convert the system from mono to stereo. It is explained in **Appendix G (Stereo Conversion).**

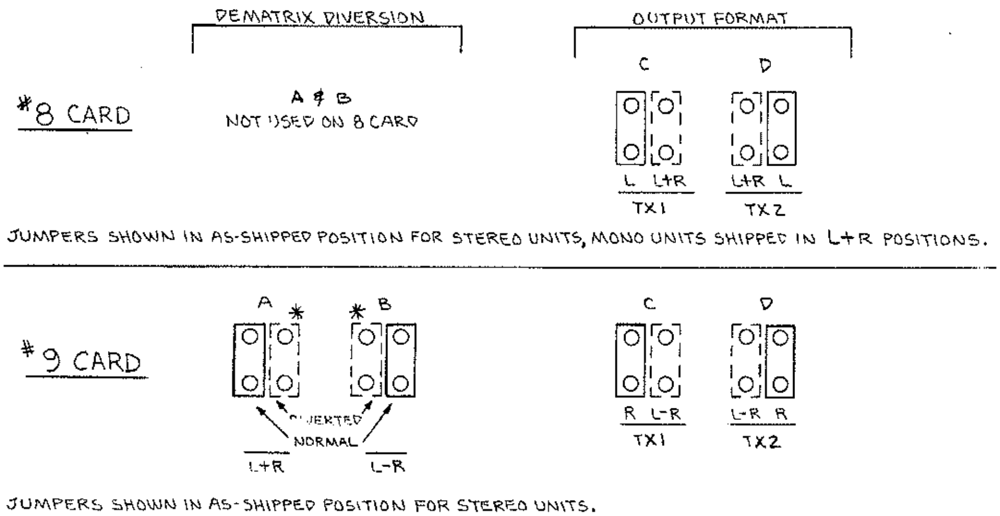
Option 2: Output Format (Cards #8 and #9): If you have the mono version of OPTIMOD-AM, this option is not relevant, and you may proceed to **Option 4.**

If you have the stereo version but are operating in mono, refer to **Mono Operation Of Stereo Units** above in this **Part.**

If you have the stereo version of OPTIMOD-AM, you must select the output format (L/R, or L+R/L-R) that the succeeding stereo generator requires. In L/R mode, a dematrix circuit is inserted before the output amplifiers; in L+R/L-R mode, this dematrix is bypassed.

As discussed under **AM Stereo** (in **Part 2),** the stereo generator may have L and R inputs, or L+R and L-R (sum and difference) inputs. If the stereo generator offers both input modes, use the L+R/L-R inputs because they eliminate a redundant matrix and dematrix and because setting modulation levels is easier in this mode. (L+R determines the amount of AM -- the "envelope modulation".)

"As-shipped", the output is in the L/R configuration. If an L+R/L-R input is available on the stereo generator, move jumpers "C" and "D" on both Cards #8 and #9 as shown below.



* WHEN DE-MATRIX JUMPERS ARE IN DIVERTED POSITION, THE DE-MATRIX IS ACCESSIBLE FROM BACKPLANE FORK TERMINALS.

Jumper "C" affects the TX1 output and jumper "D" affects the TX2 output. The "C" jumpers should be positioned identically on both cards, as should the "D" jumpers. However, since the TX1 and TX2 outputs are independent, it is possible to operate one TX output in L/R mode and the other TX output in L+R/L-R mode.

If the dematrix circuit on Card #9 has been previously diverted to another use by a special modification discussed in **Appendix I: (Application Of The Accessory Port),** only the L+R/L-R output mode may be selected.

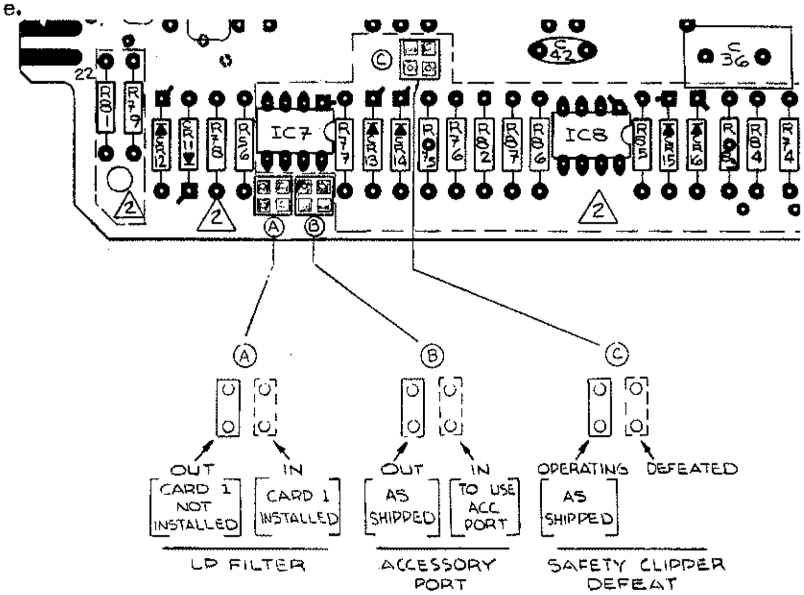
If that modification was made at some time in the past, it should have been noted on the diagram above. If jumpers "A" and "B" are in their normal positions (as shown above), then the modification was not made.

Option 3: Accessory Port Input Jumper (Cards #7 and #10): If you have the mono version of OPTIMOD-AM, this option is irrelevant and you may skip to **Option 4.**

The Accessory Port is supplied standard on all OPTIMOD-AM's but is ordinarily used only for the Kahn/Hazeltine system. (Even with this system, its use is optional.) If you are using the Kahn/Hazeltine system, refer to The **Kahn/Hazeltine System And The Accessory Port** in the **AM Stereo** section of **Various Application Notes (Part 2).**

Then turn to **Appendix I: Application Of The Accessory Port** for detailed instructions on how to interconnect your system and how to strap the relevant OPTIMOD-AM jumpers.

If, following the instructions in **Appendix I,** you have restrapped jumper "B" on Cards #7 and #10, we suggest that you mark the diagram below for future reference.

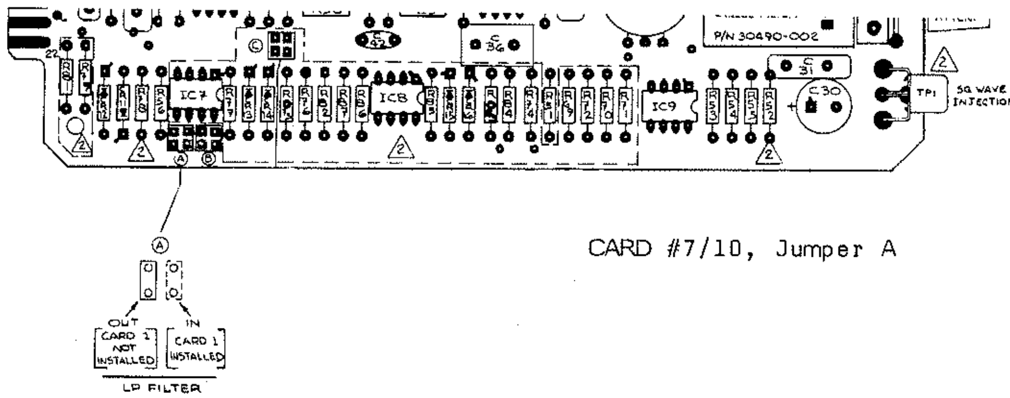


CARD #7/10 JUMPERS

If, following the instructions in **Appendix I,** you have diverted the dematrix circuit, we suggest that you mark for future reference the Card #9 jumper "A" and "B" diagrams found in **Option 2** immediately above.

Then return to **Option 4** below.

Option 4: Auxiliary Filter (Cards #7 and #10): If the optional Stereo Enhancement Card #1-S was ordered from the factory, it will be installed in card position #1, and jumper "A" will already be in the "IN" position on Cards #7 and #10 (stereo only). Otherwise, it will be "OUT".

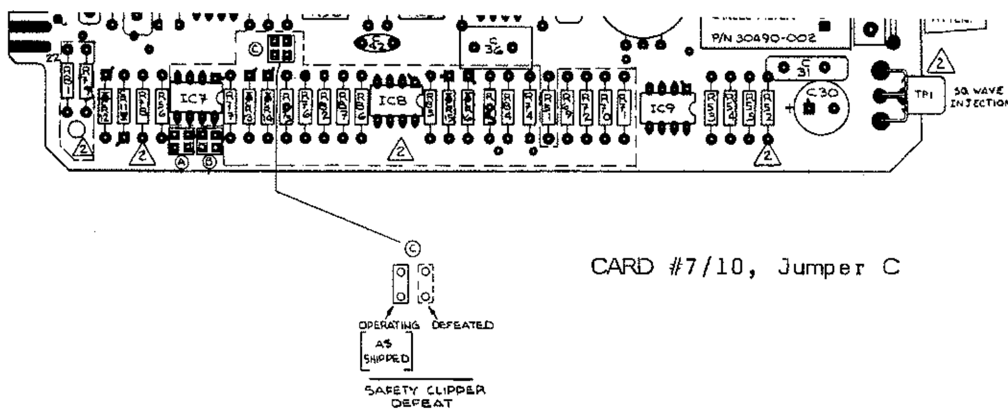


CARD #7/10, Jumper A

It is possible (but unlikely) that jumper "A" will be installed in one position on Card #7 and in the other position on Card #10 if a special-order version of card #1 was supplied.

Further information is found in **Appendix H: Installation of the Optional Filter Card.**

Option 5: Safety Clipper Defeat Jumper (Card #7): If you want to defeat the internal safety clippers [because the stereo generator is equipped with equivalent clippers -- (see **AM Stereo** in Part 2)], the safety clipper in OPTIMOD-AM can be defeated by moving jumper "C" to the "DEFEATED" position.

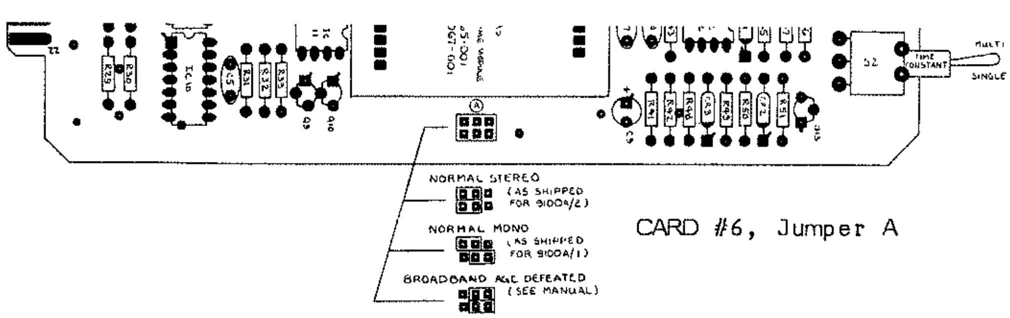


CARD #7/10, Jumper C

Jumper "C" is ordinarily shipped from the factory such that the safety clipper is operative.

Jumper "C" appears only on Card #7 in either stereo or mono versions.

Option 6: Broadband AGC Defeat (Card #6): There are two jumpers marked "A" on Card #6. These jumpers can be positioned for normal-mono, normal-stereo, or broadband-AGC-defeated operation as shown below.



CARD #6, Jumper A

If you are using an Orban 422A/424A Compressor/Limiter/De-Esser on the studio side of an STL to protect the STL from overload, the 422A/424A can be substituted for the 9100A's Broadband AGC, preventing the two units from "fighting" each other. To do this, the 9100A's Broadband AGC must be defeated. To do this, move both jumpers to the broadband-AGC-defeated position. Otherwise, they should be in the normal-mono or normal-stereo position depending on whether your unit is mono (Cards #5, #9, and #10 omitted) or stereo (Cards #5, #9, and #10 present).

Additional instructions for matching the 424A to the 9100A are found in **Part 4 (Setup Procedure).**

Option 7: HF Equalizer Modules (Cards #4 and #5): Any of three resistor arrays may be plugged into a 14-pin socket located on Card #4 (mono) and Cards #4 and #5 (stereo) units. These modules provide different curve families for the HF Equalizer. The GREEN array is installed "as shipped"; the RED and YELLOW arrays are provided in a plastic bag along with the other accessories.

Choosing the appropriate module is discussed in **High Frequency Equalizer** in **Part 1** of this manual. Further discussion is provided in **On High Frequency Equalization** in **Part 5** of this manual.

Card #1-S Jumpers: There are several jumpers which must be positioned on Card #1-S to match it to the AM stereo system in use. If your unit is equipped with the optional Card #1-S, please refer to **Appendix H** in this manual for jumper positioning instructions before proceeding to **Reassembly** below.

REASSEMBLY

When the physical examination, line voltage adjustment, and optional initialization procedures are completed, replace the subpanel. The subpanel, besides carrying knob identification and calibrations and holding the cards in place, also provides RF shielding for the cards. So, all four DZUS fasteners should be engaged by turning 1/4-turn clockwise.

The front panel may now be closed and fastened using the three hex-socket screws. Normally, all access required from now on can be achieved through the smaller access door (equipped with a key lock).
Monitor Rolloff Filter

MONITOR ROLLOFF FILTER

The Monitor Rolloff filter is a passive, unbalanced filter which must be operated between specific source and load impedances to produce the correct frequency response.

Input: If the output impedance of the source driving the Rolloff Filter (such as the output of your modulation monitor) is approximately 0 ohms (like the output of an opamp), connect this source between the "0 Ohm Source" and "Com" terminals on the Rolloff Filter. If the source impedance of the output is 600 ohms (which is available on some monitors), connect the source between the "600 Ohm Source" and "Com" terminals on the Rolloff Filter.

Output: Connect the input of your monitor amplifier between "Output" and "Com" on the Rolloff Filter. If the input impedance of your monitor amplifier is a true 600 ohms, turn the Rolloff Filter TERMINATION SWITCH off. If your monitor amplifier input is bridging (as practically all modern amplifiers are), then turn the TERMINATION SWITCH on.

Grounding: The metal case of the Rolloff Filter should be connected to earth ground to assure proper shielding. A terminal connected to the case is available on the barrier strip. The case is not connected to "Com" to avoid potential ground loops.

Part 4:
Setup Procedure

4

INTRODUCTION

This part consists of three major sections. The first describes aligning the OPTIMOD-AM Transmitter Equalizer to your transmitter and antenna by instrument. The second describes matching the Orban 422A/424A Compressor/Limiter/De-Esser to OPTIMOD-AM when the 422A/424A is employed to protect phone line or microwave STL's from overload. The third is a condensed set of operating control setup instructions, designed to help you get on the air quickly. A comprehensive discussion of the relationship between OPTIMOD-AM's setup controls and the sound produced on the air is found in **Operating Instructions (Part 5).**

BEFORE ANY SUBJECTIVE AUDIO ADJUSTMENTS ARE MADE, IT IS NECESSARY TO ADJUST THE TRANSMITTER EQUALIZER TO MATCH OPTIMOD-AM TO YOUR TRANSMITTER/ANTENNA SYSTEM.

If yours has been previously set up, you may skip to the start of the next section.

1: TRANSMITTER EQUALIZER SETUP INSTRUCTIONS

Refer to the **Transmitter Equalizer** section of **Various Application Notes (Part 2)** for a general discussion.

Stereo: In the case of a stereo installation in which the Transmitter Equalizer is usable (see **AM Stereo** in **Part 2** above for a complete discussion), the L+R/MONO control group should be adjusted first, following the instructions below. (Applying a test signal through the recommended test jack will automatically produce an L+R signal only, effectively operating the system in mono mode even if the stereo generator is in the circuit.)

The L-R controls are then adjusted by sweeping one channel only (L or R), and adjusting the L-R HF SHELVING and HF DELAY controls to null the output of the undriven channel as indicated on your stereo monitor, thus maximizing separation throughout the range of approximately 500-10,000Hz. (If a sweep generator is unavailable, the L-R controls can be set in the same positions as the L+R controls, although this may result in less than optimum separation.)

Description Of The TX EQ Controls (on the subpanel)

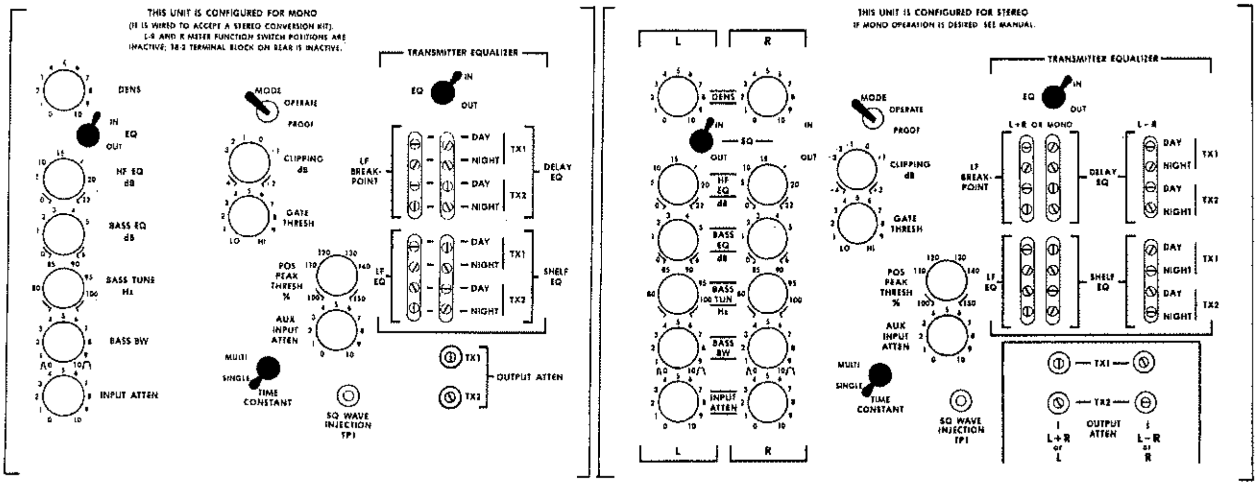
1) TX EQ IN/OUT: This switch enables or defeats Transmitter Equalization. If the system is configured for stereo, both the L+R/Mono and the L-R TX EQ are affected.

2) LF BREAKPOINT: Determines the frequency at which the response of the Tilt Equalizer section of the Transmitter Equalizer is up approximately +3dB.

3) LF EQ: Determines the maximum amount of low frequency correction provided by the Tilt Equalizer section of the Transmitter Equalizer.

4) DELAY EQ: Determines the frequency at which the Delay Equalizer section of the Transmitter Equalizer begins to add phase shift to correct for non-constant delay in the transmitter/antenna system.

5) **SHELF EQ:** Determines the frequency at which the High Frequency Shelving Equalizer section of the Transmitter Equalizer begins to roll off the high frequency response, compensating for overshoot in the transmitter/antenna system.



MONO UNIT (9100A/1) STEREO UNIT (9100A/2)

Fig. 4-1: Setup Control Layout
(See Fig. 4-6 For Recommended Initial Settings)

Setup Procedure

The following setup instructions should be repeated for each group of Transmitter Equalizer controls to be adjusted, switching to the appropriate transmitter and pattern before each new group is adjusted.

a) Obtain the following test equipment: Audio frequency sinewave or squarewave generator; oscilloscope with at least 5mHz vertical bandwidth.

b) Open the access door using the key supplied. This will expose the setup controls. (See Fig. 4-1.)

Turn the appropriate OPTIMOD-AM OUTPUT ATTEN (TX1 or TX2) fully CCW. Be sure that the carrier is off.

c) Connect the output of the audio generator to TP1 with an RCA phono plug. (One was supplied in the accessory bag.) TP1 protrudes from the subpanel containing the setup controls. Also connect the output of the audio generator to the SYNC (or EXT TRIGGER) input of the scope.

d) Connect the vertical input of the scope to a convenient source of RF, such as the transmitter sampling loop.

CAUTION!

TO AVOID POSSIBLE OVERHEATING OF THE TRANSMITTER, THE FOLLOWING ADJUSTMENT SHOULD BE PERFORMED <u>QUICKLY</u>, AND 50% MODULATION SHOULD NOT BE EXCEEDED.

e) Set the audio generator to 100Hz. Using the front-panel switches and indicator lamps, select the control group to be adjusted. Switch the TRANSMITTER EQUALIZER switch IN. Switch the MODE switch to OPERATE. Set all of the four Transmitter Equalizer trimmer controls in the group that you are adjusting fully counterclockwise except for the LF EQ control. Set the LF EQ control fully clockwise. Advance the output level of the audio generator to maximum. (If your generator can put out more than 25V p-p, do not turn the generator up past this point.)

(The test point accesses a point in the OPTIMOD-AM circuitry with very high gain. If a sinewave generator is used, the sinewave will be clipped by the OPTIMOD-AM circuitry, creating a squarewave satisfactory for this adjustment.)

f) Turn on the carrier, and advance the OPTIMOD-AM OUTPUT ATTEN control until approximately 50% modulation is observed. Adjust the scope so that it is synchronized to the audio generator. Most transmitters will produce an RF envelope resembling Fig. 4-2. Now adjust the LF BREAKPOINT trimmer control clockwise until the squarewave is as flat as possible. Fig. 4-3 shows a successful adjustment.

MAKE THE ADJUSTMENT QUICKLY TO AVOID OVERHEATING THE TRANSMITTER.

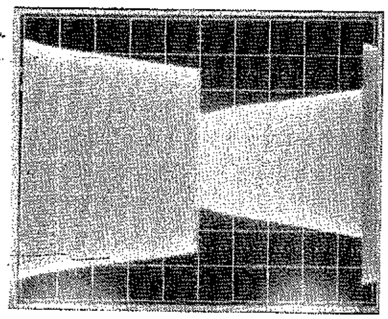


Fig. 4-2: Low Frequency Square Wave Without Tilt Correction

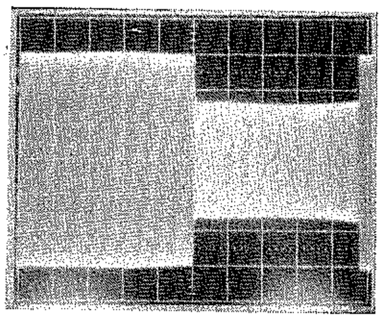


Fig. 4-3: Low Frequency Square Wave With Optimum Tilt Correction

AS SOON AS THE ADJUSTMENT IS COMPLETE, REMOVE THE 100HZ SQUARE WAVE AND ALLOW THE TRANSMITTER TO COOL DOWN FOR SEVERAL MINUTES.

If the range of the control is insufficient, this implies that transmitter bass response is inadequate and cannot be corrected without transmitter modification. (A transmitter which is not fully equalized can cost up to 4dB loudness. However, audible frequency response does not suffer because the equalization occurs below the audible frequency range.)

In many cases, this modification is easy, and merely requires replacement of coupling capacitors with capacitors of larger value. In other cases, fundamental inadequacies in the input, interstage (if used), and/or modulation transformers (if used) are indicated.

Some transmitters cannot be fully corrected because the bass boost produced by the equalizer exaggerates power supply bounce problems and/or causes actual saturation or clipping of modulator stages, transformers, reactors, etc. (see **The Transmitter** in **Part 2**). In some cases, a compromise between full tilt correction and these other problems may have to be achieved by careful experimentation with program material. The 9100A's LF EQ control is designed to permit such a compromise.

Initially, the Transmitter Equalizer was adjusted using maximum LF boost, assuring response closest to true DC-coupling, thus optimizing square wave response. If this large amount of boost at subaudible frequencies causes bounce and/or distortion on heavy bass transients in music, then the LF EQ control should be turned down until these problems are no longer observed. This will make the measured square wave response poorer. However, engineering realities force a compromise between best small signal (i.e. square wave) response, and best large signal (i.e. bounce and distortion) performance.

This compromise is best made by careful experimentation with program material, finding the adjustment of the LF EQ control which gives the highest average modulation without audible distortion.

In other cases, the tilt correction may trip overload relays on program. It is often possible to readjust the trip point of these relays to avoid this problem. However, this must be done with the greatest care, since whether the transmitter is endangered is totally dependent upon its condition.

> ORBAN ASSOCIATES INC. ACCEPTS NO RESPONSIBILITY FOR TRANSMITTER FAILURES INTRODUCED BY SUCH READJUSTMENTS, OR BY OTHER CHARACTERISTICS OF ITS AUDIO PROCESSING (SUCH AS HIGH AVERAGE POWER OR BASS AND TREBLE PREEMPHASIS).

The care and feeding of your transmitter requires application of sound engineering judgment: inadequate transmitters may fail, may have their tube life shortened, etc. Such transmitters are simply incapable of supplying the average power demands of OPTIMOD-AM processing regardless of transmitter equalization. If the station is to achieve the full benefits of OPTIMOD-AM processing, these transmitters must be either repaired, modified, or replaced.

g) **High Frequency Adjustments:** Ordinarily, the high frequency square waves used for these adjustments place less demands on the transmitter than the low frequency adjustments just performed. If these high frequency adjustments are performed at 50% modulation or less, most transmitters will not be overstrained.

Make sure that the MODE switch is in OPERATE. Modulate the transmitter to about 50% with a square wave in the region of 1 to 4kHz. Use the appropriate OUTPUT ATTEN control to adjust modulation. (As in the low frequency case, if a sinewave generator is used, the sinewave will be clipped by the OPTIMOD-AM circuitry, creating a squarewave satisfactory for this adjustment.) The frequency should be chosen so that any ringing or overshoot has time to completely settle on each cycle of the square wave.

IF NO RINGING OR OVERSHOOT IS OBSERVED, THEN SIMPLY LEAVE THE HIGH FREQUENCY EQUALIZER CONTROLS FULLY COUNTERCLOCKWISE.

The H-F SHELF EQ and H-F DELAY EQ controls are adjusted interactively. Adjust the H-F SHELF EQ until any ringing is reduced to 50% (steady-state) modulation. That is, you will still have ringing, but no overshoot.

Now adjust the H-F DELAY EQ. You will observe that it further reduces the amplitude of the ringing on the leading edge of the square wave, and introduces a new ring on the trailing edge. The idea of this adjustment is to make the amplitude of the leading and trailing edge ringing equal. In addition, both should come to 50% modulation, but should go no further.

When you adjust the H-F DELAY EQ, this usually reduces the level of the ringing to <u>below</u> the 50% modulation point. You may then back off the H-F SHELF EQ until the ringing is once again at the 50% point. This adjustment unbalances the ringing at the leading and trailing edge of the square wave, so further readjustment of the H-F DELAY EQ control is then required.

By iterating between the two controls, you will finally get to a point where the ringing at both the leading and trailing edges of the square wave reaches 50%, and is exactly equal in level to the flat portion of the square wave. Figs. 4-4 and 4-5 illustrate a typical "before" and "after" condition. (Note that the waveform produced by your particular system may be quite different than our examples.)

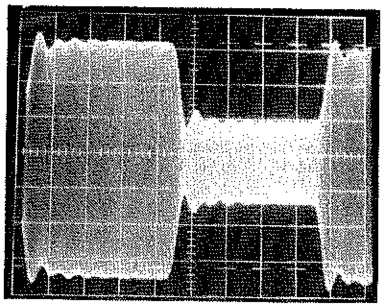


Fig. 4-4: High Frequency Square Wave Without Correction

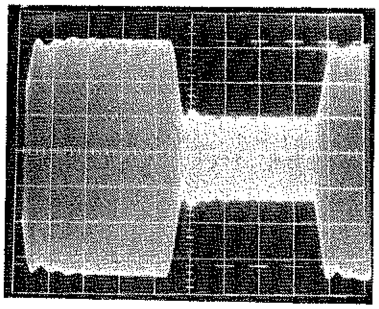


Fig. 4-5: High Frequency Square Wave With Optimum Delay and Shelf Correction

A final check should be made by sweeping the audio generator up in frequency until the square wave turns into a sine wave and finally starts to roll off in amplitude (due to natural rolloffs within OPTIMOD-AM and your transmitter/antenna system). If any overshoot over the steady state (50% modulation) point is observed as you sweep, you will have to advance the H-F SHELF EQ control slightly more clockwise to eliminate it.

Finally, make a quick sweep between 100Hz and the point where the system frequency response is substantially rolled off. At no point should you exceed 50% modulation if you have performed the adjustments of all four TRANSMITTER EQ controls correctly.

TURN OFF THE CARRIER.

If you are adjusting a 9100A/2 in a stereo installation, you must now adjust the L-R set of HF TX EQ controls to maximize separation. (See **Stereo** at the beginning of this section.)

This concludes the adjustment of the TRANSMITTER EQ controls. Be sure you have repeated the procedure independently for all of the control groups to be used in your installation.

2: MATCHING THE ORBAN 422A/424A TO THE 9100A

As described in **Initialization Option #6** (in **Part 3**), an Orban 422A (mono) or 424A (stereo) Compressor/Limiter/De-esser can be used to protect an STL from overload while simultaneously performing the function of the 9100A's Broadband AGC. In this mode, the 9100A's Broadband AGC should be defeated as described above.

IF YOU ARE NOT USING AN ORBAN 422A/424A, THEN SKIP TO **INITIAL AUDIO PROCESSING ADJUSTMENTS** BELOW.

The 422A/424A is adjusted in a slow averaging mode of operation to assure best psychoacoustical matching to the 9100A. This means that the peak output level is not tightly controlled, and that some headroom above average 422A/424A output levels must be provided in adjusting the STL modulation to accomodate transient overshoots.

To properly match the 422A/424A to the 9100A, we recommend the following 422A/424A control settings:

INPUT ATTEN	Adjust to produce the desired amount of gain reduction in the 422A/424A with normal levels from the console. 10dB G/R is typical.
COMPR. RATIO	infinity:1 (Classical or other wide dynamic range formats may wish to use a gentler ratio to achieve more subtle compression.)
ATTACK TIME	8.0
REL SHAPE	LIN
REL TIME	7.0
GATE THRESH	3 to 5, depending on noise level of program material
OUTPUT TRIM	adjust until the VCA LEVEL meter occasionally hits "+2" during heavy transients
IDLE GAIN	-10 (or whatever average gain reduction you are using)
COMP/LIM OP/DEFEAT	OP
DE-ESSER OP/DEFEAT	DEFEAT (If the STL is preemphasized, the de-esser might be useful as an HF limiter. See the 422A/424A OPERATING MANUAL for a further discussion.)
STEREO COUPLING	COUPLED
OUTPUT LEVEL (rear panel)	Adjust for correct STL modulation on material with heavy transients. Absolute limiting of the 422A/424A peak output level occurs whenever the VCA LEVEL meter reads "+2", indicating VCA clipping.

Set the 9100A's GATE THRESHOLD control FULLY CLOCKWISE.

When the Broadband AGC jumpers in the OPTIMOD are in the defeated position, the BROADBAND AGC G/R METER will always read "0", and no AGC action can occur. For this reason, it is important to set the L INPUT ATTEN and R INPUT ATTEN sufficiently conservatively to avoid clipping the Broadband AGC VCA, which is still in the circuit despite the fact that its control circuitry has been defeated. This can be assured by adjusting the L and R INPUT ATTEN controls such that the 9100A's front-panel VU meter never exceeds -6VU in the L AGC and R AGC positions of the METER FUNCTION SWITCH.

3: INITIAL AUDIO PROCESSING ADJUSTMENTS

Introduction: The instructions below refer to a mono installation. In a stereo installation, corresponding left and right channel controls should be adjusted simultaneously, and their settings made as equal as possible with reference to the dial calibrations. In **Stereo Matching of Setup Controls (Part 5),** a procedure is described for matching the channels as closely as possible by nulling the L-R output of the matrix on card #5.

a) Below, you will find TYPICAL CONTROL SETTINGS which should produce an open, non-fatiguing, yet competitively loud sound. We feel that these settings are a good starting point for most formats. The next part of this manual provides detailed information which will help you "customize" the settings for your format and target audience.

Talk formats have special requirements; the Auxiliary Input may be useful [see **Various Application Notes (Part 2)**].

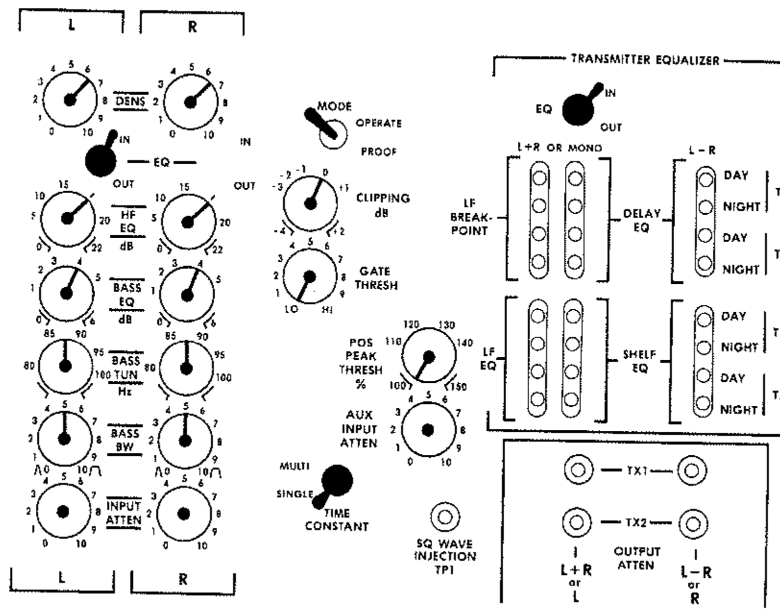


Fig. 4-6: Recommended Initial Control Adjustments

Now adjust all controls except for the INPUT ATTENUATOR and OUTPUT ATTENUATOR to match the TYPICAL CONTROL SETTINGS. (For the moment, adjust the INPUT ATTEN and OUTPUT ATTEN controls fully counterclockwise.)

b) Adjust the three mode switches as follows:

EQUALIZER:	IN
TX EQ:	IN
MODE:	OPERATE

Drive the program line with typical levels. Adjust the INPUT ATTENUATOR until the BROADBAND AGC G/R meter reads about "0" (corresponding to 10dB gain reduction). If this amount of gain reduction cannot be obtained, refer to **Initialization Option #1** in **Installation (Part 3).**

c) Using normal program material, trim the DENSITY control(s) as necessary to achieve approximately 10dB G/R as indicated on the two middle BAND LIMITER G/R meters. The GATE LED should light during pauses in the program, and the BROADBAND G/R meter should "freeze". (During a very long pause, it will slowly drift to "0"). If these indications seem abnormal, check to see if you have correctly adjusted the controls according to the TYPICAL CONTROL SETTINGS sheet. If not, a malfunction in the OPTIMOD-AM internal circuitry, or an installation problem should be suspected.

d) For cleanest sound, we recommend that the POSITIVE PEAK THRESHOLD control be adjusted fully CCW to "100%", so that symmetrical operation is achieved. This is particularly important in stereo. A full discussion is found in **Asymmetry** in **Various Application Notes (Part 2).**

However, if absolute maximum loudness is desired (at the expense of cleanest possible sound) the POSITIVE PEAK THRESHOLD control may be advanced as far towards 125% as desired.

e) Turn on the carrier. Advance the appropriate OUTPUT ATTENUATOR control (TX1 or TX2) until substantial modulation is observed.

f) Temporarily advance the POSITIVE PEAK THRESHOLD control to 125%. Using your modulation monitor, check modulation symmetry. If negative peaks are modulating higher than positive peaks, reverse the polarity of the OPTIMOD-AM output cable. [In a stereo installation, reverse the polarity of both lines feeding the stereo generator to preserve phasing (in L/R output mode) or to preserve L and R channel identity (in L+R/L-R output mode).]

g) Advance the OUTPUT ATTENUATOR controls until desired modulation levels are achieved. In stereo operation, this is most easily done if the output is strapped in the L+R/L-R mode, since the L+R OUTPUT ATTEN can be advanced for correct envelope modulation, and then the L-R OUTPUT ATTEN can be advanced until best separation is achieved.

If the 9100A is strapped in the L/R mode, both L and R OUTPUT ATTEN controls should be advanced together. Drive both L and R inputs with identical (mono) signal, and use the front-panel L and R SYSTEM OUT meter positions to make sure that the channels are staying in balance as you adjust the OUTPUT ATTEN controls.

If all is well, the negative peaks of envelope modulation will usually "hang" close to 100% at all times except during pauses. (Envelope modulation is the modulation as read on your conventional mono modulation monitor. We expect that all stereo monitors will also be able to read it, as it represents the "AM" component of modulation.)

IF YOU CHOOSE TO MODULATE ASYMMETRICALLY, YET THE TRANSMITTER IS OBSERVED TO COMPRESS PEAKS IN THE POSITIVE DIRECTION, DO NOT ATTEMPT TO MODULATE FULLY TO 125% POSITIVE. This will only cause distortion above and beyond the distortion intrinsic to asymmetrical operation.

Note too that the distortion of transmitters and receivers tends to increase radically when negative modulation of more than 85% is attempted. In the case of receivers, the major cause of this distortion is cheaply-designed envelope detectors whose diodes are not correctly biased. Serious consideration should be given to the possibility of reducing clipping in the processing such that the last 15% or so modulation consists of low duty-cycle "spikes" which can be in effect "soft-clipped" by the radio's detector, trading off about 1.5dB loudness loss for substantially cleaner sound.

h) Check audio quality with an AM radio, or with the modulation monitor aural output with the monitor rolloff network in place (see **Monitor Rolloff Network** in **Part 2).** If distortion or other problems are observed, refer particularly to **The Transmitter** in **Part 2.** And be sure that the source material at the OPTIMOD-AM input terminals is clean.

Part 5:
Operating Instructions

This section is written for both Program Directors and Chief Engineers, with the hope that it will ease their way toward getting good sound.

THE BASICS

A perfectly-designed audio processor would allow you to trade off three fundamental factors. Each could be improved at the expense of the others. These factors are:

1) LOUDNESS
2) BRIGHTNESS
3) DISTORTION

Historically, a fourth, non-fundamental factor has always entered into consideration. This factor is the presence of processing artifacts, generated by imperfect psychoacoustical design of the audio processor. These artifacts are the audible side-effects of audio processing, including "pumping", "breathing", "hole-punching", and "noise pull-up". OPTIMOD-AM has reduced these artifacts to an unprecedented minimum by revolutionary circuit and system design. You are therefore free to play-off loudness against brightness against distortion without worrying that you will be limited by unwanted side-effects unrelated to the basic limitations of the AM radio medium.

The technical details of how Orban achieved this reduction in artifacts are probably not important to you -- but it is important that you understand the operating controls, and how they relate to the fundamental tradeoffs, and to your air sound. Only in this way will all of OPTIMOD-AM's potential be available to you.

WHERE TO START

Start by

1) Identifying your competition, and listening to them analytically; and, by

2) Developing a set of "reference radios" with which you are familiar, and which are similar to those used by a majority of your audience. Too often, just one radio (usually the PD's car radio) is used. This is unwise.

At this writing (early 1985), we can divide AM radios into three major groups according to their high frequency response. The first group consists of a few wideband AM stereo radios (like the 1984-1985 Delcos) which may have flat response to 5kHz or above. The second group is radios which have a response which is down -3dB at approximately 2kHz, but whose rolloff above that point is gentle enough to allow preemphasis to be employed advantageously in brightening the sound. The third group is radios which are also down -3dB at 2kHz, but which roll off so steeply beyond this frequency that it is impossible to create a preemphasis curve which would be of benefit. In our opinion, this third category must be written off as producing hopelessly bad sound. It is unlikely that any more than a few consumers could listen with enjoyment to music on such radios; they are mainly useful for talk programming or for repelling pigeons and muggers.

The vast majority of present-day radios are in the second and third categories.

The task of choosing reference radios (and for that matter, of choosing the amount of high-frequency boost to use) has been complicated by the advent of new broader-band AM stereo radios. The 1984 and 1985 Delco AM stereo radios have a frequency response which is almost flat to 5kHz and which rolls off sharply thereafter. (However, we do not expect Delco to produce radios with this type of frequency response characteristic past the 1986 model year. We expect 1987 and later model Delcos to have a frequency response which better complements real-world audio processing.)

If you are broadcasting in C-QUAM stereo, it is unfortunately necessary to choose whether you will process for the vast majority of conventional narrowband radios or for the few wideband stereo radios. The 9100A's RED and YELLOW equalization modules -- see **High Frequency Equalizer** in **Part 1** of this manual -- have been designed to help you make the compromise between the two types of radio with minimum pain.

In all cases, bass performance is <u>completely</u> unpredictable from model to model and does not necessary correlate to high frequency response.

At the moment, the best-sounding AM receiver we know of is the Sony SRF-A100 AM stereo radio. It is switchable between "wideband" and "narrowband" modes. Fortunately, its "wideband" mode rolls off gently and does not introduce the stridency and irritation that the 1984-1985 Delco AM stereo radio's wideband mode does. (Use headphones or drive an external amplifier and speaker with the Sony's headphone output; its own tiny speakers cannot be used for reference purposes.) Operated in WIDEBAND mode with the tone control at "1:00", the Sony's response fairly closely approximates our "recommended standard de-emphasis curve for AM receivers". (This de-emphasis curve is an effective compromise between "wideband" and "narrowband" receivers. It is further discussed in a technical paper called "AM Broadcast And Receiver Standards -- Towards Opening A Dialogue" by Robert Orban and Greg Ogonowski. A copy is available upon request <u>in writing</u> from Orban customer service.)

A representative good-sounding narrowband radio is the General Electric "Superadio". Our former recommended reference -- the Radio Shack MTA-7 -- was discontinued some years ago. Its replacement has inferior sound and is not recommended.

Identifying the competition's sound is important, too. Stations in some markets tend to use large amounts of high frequency equalization to overcome the large amounts of rolloff in most radios; other markets tend to be more conservative. The ideal is to sound significantly <u>better</u> than the competition, without being so stunningly <u>different</u> that your audience might become alienated. It's best to proceed in medium-sized steps rather than in one giant leap! In particular, if your market is not engaged in a "loudness war", you can use less processing, and trade loudness for reduced distortion, more brightness, and greater apparent fidelity. On the other hand, if a "loudness war" exists, OPTIMOD-AM can be a lethal weapon when properly set up.

If your competition already has OPTIMOD-AM, then it is up to you to use the utmost taste and judgement in setting your processor up. If two or more OPTIMOD-AM stations get into a loudness battle (presuming RF plants of equivalent quality) then the loser can be <u>each</u> station as listeners are driven to FM because of fatigue due to overprocessing. Don't lose your perspective: loudness isn't everything! With taste and care, OPTIMOD-AM can make AM into a <u>quality</u> medium which can seriously compete with FM's on smaller radios and in cars.

Monitor Rolloff Filter: Note that the sound from the off-air monitor system in your station is usually totally unrelated to your air sound -- because your monitor is not rolled off like a real AM radio. You can't accurately judge the OPTIMOD-AM processed signal on a flat monitor -- it will sound shrill and unpleasant unless very little equalization is used in OPTIMOD-AM.

A special Monitor Rolloff Filter is included with each OPTIMOD-AM. This Rolloff Filter is adjustable to complement the HF EQ setting you have chosen on the processor. To achieve the most pleasing sound, the Monitor Rolloff Filter does not attempt to simulate the rolloff of a real AM radio in the frequency range above 5kHz or so (depending on the setting of its ROLLOFF control). Instead, above this frequency, it stops rolling off. The net result is that the extreme highs from 5 to 12kHz are neither exaggerated (as they would be if no filter were used), nor rolled off (as they would be if the Rolloff Filter simulated a typical radio response all the way to 12kHz). Thus, the monitor sound is subjectively "flat" and high fidelity, and is quite useful in revealing distortion problems or other problems with audio quality. However, it is not suited for use as a reference to adjust the OPTIMOD-AM HF EQ controls because its response does not resemble that of a real radio.

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The Rolloff Filter should be adjusted after you have chosen your final settings of the OPTIMOD-AM operating controls. Switch your monitor speakers between "Program" and "Air", and adjust the ROLLOFF control on the filter to achieve the best match by ear. (Because the Six-Band Limiter performs an "automatic equalization" function, it will not be possible to achieve a consistent match on all program material, and a reasonable compromise should be made.)

The Monitor Rolloff Filter was designed to complement the curves produced by the GREEN EQ module. Presence will be lost if either of the other modules is used. A 5-band graphic equalizer placed in the line before the monitor amplifier might be useful to optimize the subjective quality of the monitor if the RED or YELLOW EQ modules are used in the processor.

Subjective Adjustments For AM Stereo: In stereo installations, we recommend performing the subjective adjustments in mono first. Alternately, you can adjust both L and R controls simultaneously, matching them as well as you can on the basis of panel calibrations. After you are satisfied, the two stereo channels can then be precisely balanced by the L-R nulling technique discussed later in this **Part** in **Stereo Matching Of Operating Controls.**

FUNCTIONS OF THE OPERATING CONTROLS

At this point, it seems appropriate to present a condensed description of each of the operating controls. After all of the controls are introduced, we will discuss in detail how the controls relate to the 9100A system and how they may be adjusted to obtain your desired "sound".

In a stereo unit, all of these controls are duplicated for the left and right channels, except as noted.

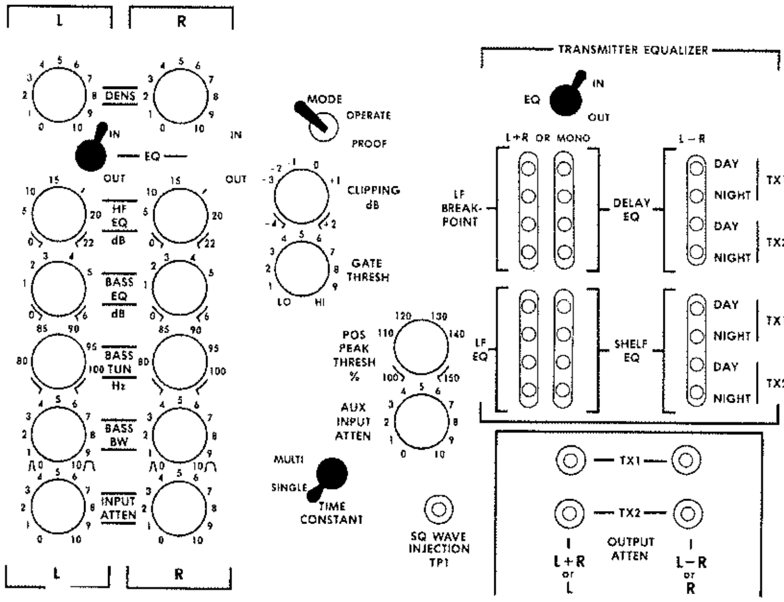

Fig. 5-1 Operating Controls
(Stereo Unit Shown)

1) **INPUT ATTENUATOR:** Determines the amount of compression in the Broadband AGC (for a given audio level entering the processor), and therefore how much the loudness of soft program material is increased. OPTIMOD-AM has been designed to work best with a nominal broadband AGC gain reduction of 10dB (corresponding to "0" on the G/R meter).

[In stereo units, the amount of gain reduction in the Broadband AGC is determined by the sum of the left and right channels, despite the fact that the signal has not yet been matrixed into L+R and L-R. Therefore, if your unit is a 9100A/2 (stereo), but you are operating in mono, you should drive both left and right inputs in parallel and adjust both L and R INPUT ATTEN controls to identical dial settings. Otherwise, gain reduction will be about 6dB lower than optimum, resulting in excessively high levels in the Broadband AGC's VCA.]

2) **BASS BANDWIDTH:** Determines whether the Bass Equalizer will affect a broad or a narrow band of frequencies surrounding the frequency determined by the BASS TUNING control. "Q" is variable through a range greater than 0.3 to 1.4.

3) **BASS TUNING:** Determines the frequency at which the maximum bass boost will occur, 70 to 110Hz. The Bass Equalizer produces a "peaking" (i.e., bell-shaped) curve.

4) **BASS EQ:** Determines the amount of bass boost provided at the frequency specified by the BASS TUNING control. Boost is variable from 0 to +6dB.

5) **HF EQ:** Determines the maximum amount of HF boost provided, from 0 to 22dB. The setting of this control determines the frequency to which the perceived bandwidth of an "average" AM radio is extended, from 2 to 6kHz. The shape of the curve is "third-order shelving". Note that the GREEN, YELLOW, and RED modules (installed in sockets on Cards #4 and #5) will produce three different families of curves. The families of curves produced by the HF Equalizer are shown in Fig. 1-2 (in **Part 1** of this manual).

6) **EQ IN/OUT SWITCH:** Determines if the LF and HF equalizers are active.

7) **DENSITY:** Determines how hard the Six-Band Limiter section is driven, and therefore how much this section will increase the density (i.e., short-term average power) and loudness of the signal.

The gain reduction in the Six-Band Limiter is determined by the setting of this control, and by the CLIPPING control. The unit has been designed to sound best when the DENSITY control is adjusted to produce no more than 10dB G/R in the two middle bands. The top bands may safely exhibit much more G/R, particularly with bright program material and with large amounts of HF EQ.

8) CLIPPING: Determines how hard the Multiband Distortion-Cancelled Clipper and safety clipper are driven, and therefore how much peak control is achieved by clipping. The loudness/distortion tradeoff is primarily determined by this control. However, for a given setting of the CLIPPING control, perceived clipping distortion will increase as the DENSITY control is advanced, and the CLIPPING control may have to be turned down to compensate.

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The CLIPPING control is a threshold control for all bands in the Six-Band Limiter. Therefore, as the CLIPPING control is turned down (counterclockwise), the threshold of the Six-Band Limiter is lowered and more gain reduction occurs, decreasing average levels into the clippers.

The range of the control is -4 to +2dB. We believe "0dB" to be an excellent compromise between loudness and distortion when the unit is set up close to our "Initial Recommended Settings".

This control affects both L+R and L-R simultaneously in stereo units. Since L-R is usually lower than L+R, more clipping will ordinarily occur on the L+R channel.

9) GATE THRESHOLD: Determines what input level the system considers to be "noise". Below this level, the release time of the Broadband AGC is slowed by a factor of 10 or so to prevent "breathing" and the Broadband AGC releases towards 10dB gain reduction ("0" on the G/R meter).

This control affects both L and R channels in stereo units. The gating control circuitry senses L+R.

10) TIME CONSTANT Switch: This switch affects the attack and release characteristics of the Broadband AGC <u>only</u>.

SINGLE creates a very slow attack and release, and forces the Broadband AGC to act as a true averaging device. SINGLE mode sounds most musically natural.

MULTI speeds up the attack on transients which significantly exceed the average program level. It also momentarily speeds up the release after a transient. This mode is useful if extremely wide variations in input level occur, since it will correct such level variations more quickly than SINGLE. An example is a talk format with considerable live material. However, MULTI will create a slight loss of musical solidity compared to SINGLE, and is therefore recommended only if wide input level variations are inevitable and frequent.

In stereo units, both channels are affected.

11) MODE Switch: This switch enables you to do a Proof of Performance as specified in the FCC Rules (U.S.A.). It defeats all clipping and sets the control voltages for all VCA's within the system to a constant level. It also activates the Gate, resulting in the Broadband AGC's taking 10dB of gain reduction.

In stereo units, both channels are affected.

The MODE Switch does not bypass any active circuitry.

12) POS PEAK THRESH: This control varies the clipping symmetry in both the Multiband Distortion-Cancelled Clipper and Safety Clipper. Positive peaks are adjustable from 100% to 150% modulation, while negative peaks stay constant at 100%.

Cleanest sound results from symmetrical operation (i.e., 100% positive peaks). Reasons for this are discussed in **Asymmetry** (in **Part 2**).

In stereo units, both L+R and L-R are affected. When operating asymmetrically in stereo, this can result in asymmetrical non-linear separation. Symmetrical operation is particularly recommended in this case.

13) AUX INPUT ATTEN: This control varies the sensitivity of the Auxiliary Input over a 26dB range.

14) OUTPUT ATTEN (x2-mono; x4-stereo): Determines the drive level to each of the balanced program amplifiers. In mono, one program amplifier is provided for each of two transmitters; in stereo, a pair of program amplifiers is provided for each of two transmitters. These pairs of amplifiers can be strapped to provide L and R, or L+R and L-R signals.

The **TX EQ** setup controls are used to match OPTIMOD-AM to your transmitter by instrument. They are described in **Setup (Part 4)**.

RELATING THE OPERATING CONTROLS TO YOUR DESIRED SOUND

The above discussion of the operating controls should be sufficient to get you started. However, to use OPTIMOD-AM's power to best advantage, it is important that you understand some of the more subtle details of OPTIMOD-AM, and how they relate to your system and desired "sound". This is discussed next.

The operating controls (particularly the equalizer controls) on your OPTIMOD-AM Model 9100A were very carefully limited in their range of adjustment to avoid problems with misadjustment. We have used the experience of the hundreds of users of our older OPTIMOD-AM Model 9000A to zero-in on a range of control settings which help you achieve a universally pleasing sound -- without leading you astray!

We think you will find OPTIMOD-AM Model 9100A easy and "friendly" to set up. You really have to work hard to sound "bad"! Because of the increased sophistication of the HF Equalizer (which paradoxically results in simplified user controls), and because of the elimination of the old Model 9000A's "Smart Clipper", setup is much easier than it was for the 9000A.

So don't be intimidated by the length of the following discussion: we think you'll be able to find a better "sound" than you were ever able to achieve with any other processor -- and to find it quickly and easily (once you understand the rules!).

EQUALIZATION: THE FIRST PRIORITY

The built-in, fully-adjustable program equalizer in your OPTIMOD-AM was designed after exhaustive research into the characteristics of various randomly selected AM radios in the "car", "table", and "pocket portable" categories. There are only four equalization controls, only <u>one</u> of which affects the highs. Yet far more accurate curves can be obtained than you could get with any conventional graphic or parametric equalizer. We have found the **Recommended Initial Control Settings** found in **Part 4** above to be an excellent compromise for most music formats. For the moment, we recommend that you start with these settings and experiment until your personal tastes are satisfied. After you make a change, <u>listen for a while</u> -- make sure that your sound is good with different voices, with different kinds of music within your format, with commercials, and with low-quality material like telephone and shortwave. And make sure the sound is good on <u>all</u> your reference radios -- don't fall into the trap of overequalizing bass.

On High Frequency Equalization: The OPTIMOD-AM high frequency equalizer with GREEN module (as shipped) was designed to equalize the average high frequency response of fifteen common AM radios up to a high frequency limit adjustable with the HF EQ control. This limit is variable from 2kHz (i.e., no equalization at all) up to 6kHz. 6kHz requires about 22dB of ultimate high frequency boost, and is therefore the practical limit to which the subjective frequency response of the radio can be extended. Attempts to boost more than 22dB would result in problems with tuning ease, and would require enough HF limiting to create disturbing peculiarities in certain types of program material.

The effect of high frequency boost is very different on radios with gentle rolloffs than on radios with steep rolloffs (i.e., groups two and three). Many steep-slope radios cut off frequencies around 10kHz so completely that these frequencies cannot be heard or detected, even slightly. Conversely, gentle-slope radios have sufficient response around 10kHz so that the presence of highly boosted material in the 10kHz region is easily perceived as a sense of "air" or "transparency" which is usually totally missing from AM reception. OPTIMOD-AM can provide sufficient boost to provide this sense of transparency on the gentle-slope sets. In our experience, it is impossible to make the "steep-slope" (group three) radios sound good regardless of how heroic the processing effort might be!

Table 5-1 below correlates the amount of HF EQ (as indicated by the panel calibrations) with the subjective bandwidth of the "average" AM radio at a given HF EQ setting, with the GREEN module installed.

Table 5-1

HF EQ (dB)	Perceived Bandwidth
22dB	6kHz
20dB	5.7kHz
15dB	5kHz
10dB	4kHz
5dB	3kHz

Setting the HF EQ control on the mark between "15" and "20" and installing the GREEN module creates our "Recommended Standard Preemphasis For AM and AM Stereo Broadcast". We are proposing this curve as a de-facto standard to permit receiver manufacturers to design radios which create a sound competitive with FM when receiving such preemphasized signals.

Tuning ease is important. The more high frequency boosting you do, the more carefully the listener will have to tune his radio. On the other hand, the brighter and closer to high fidelity will be the sound quality he receives. Each station must use its own careful judgement here. Experimenting by tuning your reference radios

Extreme amounts of HF boost may result in a slight "lisping" quality with certain voices. This is because OPTIMOD-AM can produce a very loud sound on voice. Simultaneously, sibilance can only be boosted to 100% modulation. If the relative balance between sibilance and "voiced" sounds is radically changed (because of extreme HF limiting of the sibilance), the ear may interpret this as a "lisp". This will ordinarily be observed only if OPTIMOD-AM is adjusted very aggressively for maximum loudness. Under these circumstances, it may be desirable to reduce the HF EQ to 15dB, which will still give a bright, well-defined sound.

If less loudness and density are desired to create a more open, FM-like sound, then the full range of the HF EQ can be used freely.

If you use a very conservative amount of HF EQ (between 0 and 12dB), then the RED or YELLOW modules will produce smoother sound than the GREEN module -- even if you are targeting your processing to typical narrowband radios. This is because with less than 12dB HF EQ, the "presence peak" produced by the GREEN module moves down from the 5kHz into the 3kHz range. The subjective quality of a slight 3kHz peak is far less attractive to the ear than the subjective quality of a 5kHz peak. Thus the GREEN module sounds best when used with more than 12dB of HF EQ; the RED and YELLOW modules (which produce no peaking) sound best when less EQ is used.

If your target audience has a significant number of wider-band AM stereo radios, and particularly if you are broadcasting in stereo, you may again wish to use the YELLOW or RED modules instead of the GREEN module. The effect of the YELLOW and RED modules is to 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 radios like the 1984-1985 Delco AM stereo set.

At this writing, we have indications that this kind of response will not be continued in future model years, and that future Delco radios will be designed to be much more compatible with existing audio processing practices. If this turns out to be the case, the 1984-1985 Delco stereo radios may be "orphans" or aberrations, in that the population of these radios will be small by comparison to the total number of radios in the hands of your listening audience, and that less attention therefore need be paid to equalizing for the peculiar and unconventional frequency response of these sets.

You will notice that the RED module, like all the others, is up 3dB at 2kHz, and that its compromises occur in the 5kHz region. This is because the vast majority of radios are down -3dB at 2kHz, and the RED module therefore represents our best effort to compromise between the needs of the wideband stereo radios and the needs of the conventional sets. At this writing, we do not believe that it is appropriate to equalize for the wideband stereo radios only, because this would cause a severe loss of presence on the conventional sets.

On Low Frequency Equalization: A certain amount of low frequency boost must be used along with the high frequency boost in order to obtain a balanced sound. The watchwords are: BE CONSERVATIVE! Use the bassiest of your auto radios (all of which usually have a peaky midbass when you listen through the standard dashboard speaker) as a "worst case" reference. Do not boost the bass so far that your reference radio becomes muddy or boomy. A correct bass boost will cause your table radio to have only moderate bass, and your pocket radio to sound thin and tinny.

Because bass equalization is so dependent on individual taste, we have made the bass equalizer fully-parametric. This means that you have control over three parameters:

1) the frequency at which the largest boost occurs;
2) the amount of boost at that frequency; and,
3) the bandwidth -- the number of frequencies on either side of the largest-boost frequency which are also affected by the boost.

Because of the danger of over-equalizing bass, we have purposely limited the available bass boost to +6dB. Bear in mind that this represents a power increase of 4x! Boosts in excess of 6dB will cause many dashboard speakers to become unacceptably muddy-sounding, and will also strain many transmitters, increasing power supply bounce and IM distortion problems unnecessarily.

Use of a narrow bandwidth, a low boost frequency, and a relatively large boost can give a very "punchy", "kicky" sound in a car, or on a radio with significant bass response. It can also cost you loudness (bass frequencies take lots of modulation without giving you proportionate loudness), and can result in thin sound on radios with only moderate bass response. A smaller amount of boost, a medium boost frequency, and a moderate bandwidth usually give a better compromise.

It is important to understand that the effect of the OPTIMOD-AM Bass Equalizer controls is relatively subtle. This is because bass balances are also affected by the action of the 150Hz and 420Hz bands of the Six-Band Limiter and following Multiband Distortion-Cancelled Clipper. These bands will tend to make bass balances more uniform (partially "fighting" bass-balance changes made with the Bass Equalizer) by increasing bass in program material which is "thin"-sounding, and by limiting heavy bass to 5dB below 100% modulation to prevent disturbing intermodulation between bass and higher-frequency program material.

(The Multiband Distortion-Cancelled Clipper prevents hard-clipped bass squarewaves from appearing at the OPTIMOD-AM output. You may well discover that older transmitters respond much better to this well-controlled, benign waveform than to the hard-clipped bass squarewaves produced by less sophisticated processing.)

LOOKING AT THE REST OF OPTIMOD-AM

We have started with the specific: the OPTIMOD-AM program equalizer. This is because the equalizer is the single most important factor affecting the sound of your station. However, to understand how OPTIMOD-AM can control your loudness, distortion, density, and dynamic range, it's essential to learn more about the rest of the OPTIMOD-AM system.

Broadband AGC: Gain is ridden on the raw sound from the program line by the OPTIMOD-AM Broadband AGC. This is designed to control average levels, and to compensate for a reasonable amount of operator error. It is specifically not designed to substantially increase the short-term program density. This task (which helps increase loudness) is better performed by the Six-Band Limiter and Multiband Distortion-Cancelled Clipper sections which follow.

The Broadband AGC has a 25dB range. This is plenty to handle any reasonable operation -- only gross sloppiness on the part of the board operator will result in exceeding its range. However, be warned that the habit of some D.J.'s of peaking the music low and hitting the pin of the VU meter on voice will result in improper on-air balances. OPTIMOD-AM maintains an impression of short-term dynamic range. This is one of the keys to its preservation of musical quality and to its lack of processing artifacts. In the case of the D.J. who pegs the meter, OPTIMOD-AM "sees" exactly what's happening: a very loud sound (voice) surrounded by much softer sounds (music). It therefore maintains this impression on the air. The cure is simple: peak voice and music closer together.

(In fact, best on-air balances can often be achieved by peaking voice 3-5dB below music.)

**IF IT SOUNDS RIGHT ON THE PROGRAM LINE,
IT WILL SOUND RIGHT ON THE AIR!**

The Broadband AGC is gated: its release time slows radically if the level coming into OPTIMOD-AM goes below a level that you can select with the GATE THRESH control.

The Broadband AGC is designed to operate in the region of 10dB G/R ("0" on the meter) with normal drive levels. If the unit is gated for a significant length of time, you will see the Broadband G/R settle slowly to 10dB ("0" on the G/R meter). In the absence of signal level sufficient to ungate the unit, the gain thus eventually drifts to "normal". This is to avoid long periods of excessively high or low gain which could cause audible noise (high gain) or undermodulation (low gain).

The adjustment of the GATE THRESH control depends heavily on your format. If you use mostly high-quality program material, you will want to set it low (towards the counterclockwise end of the scale). If there is considerable noisy material like telephone conversations, shortwave broadcasts, sports remotes, and the like, then the threshold should be set higher so that noise is not "pumped up" during pauses.

If you hear soft passages in music fading away, then the GATING THRESHOLD control is probably set too high (or the operator is peaking too low). If background noise is heard to rise slowly during pauses, then the control is set too low. For most formats, this control should be set fully counterclockwise.

Six-Band Limiter: The program equalizer that we discussed initially follows the Broadband AGC. After the equalizer comes the Six-Band Limiter.

The Six-Band Limiter has two main tasks:

1) It increases loudness by increasing the density of the program; and,

2) It corrects the frequency balance of substandard program material automatically, helping give the highly sought-after "uniform sound" without critical manual re-equalization of every piece of program material in the production studio.

By "density", we mean how uniform the loudness is. Programs with large amounts of short-term dynamic range are not dense; very highly compressed programs are generally much denser. The trick in audio processing for loudness is to increase program density without introducing unpleasant side effects.

We recommend that the Six-Band Limiter be driven relatively hard -- so that gain reduction in the middle bands is typically 10dB. Only in this way will its advantages in obtaining high loudness be fully utilized. In conjunction with the Multiband Distortion-Cancelled Clipper (the two circuits are so intimately connected that they could almost be considered as one), the Six-Band Limiter can compress short-term dynamic range with fewer audible side-effects than any other section of OPTIMOD-AM. However, if it is driven too hard, there are a number of potential problems:

1) An apparent increase in background noise;

2) Excessively loud breath sounds on voice;

3) Potential "lisping", (as discussed above in **On High Frequency Equalization)**;

4) A squashed, somewhat "phasey" high end (which sounds like phase cancellation between bands, but isn't -- the actual mechanism is quite complex and not worth discussing here); and,

5) An increase in clipping distortion.

Problems (1) and (2) indicate that too much gain reduction is being used in the Six-Band Limiter: back off the DENSITY control. Problems (3) and (4) can be resolved by backing off the HF EQ and/or the DENSITY controls.

Problem (5) can be resolved by backing off the CLIPPING control. This control affects how much level control is produced by gain reduction, and how much by clipping. It should be advanced clockwise until the amount of distortion produced by the processing becomes excessive, and then backed off slightly. The more clipping that is used, the louder the on-air sound. It is thus important to carefully and critically adjust the CLIPPING control just below the point where clipping distortion begins to be disturbing if maximum loudness is to be obtained. Usually a live announcer is the most sensitive test for audible "fuzziness". Use your medium bandwidth reference radio for this test -- the station monitoring system will reveal distortion you could never hear on the average radio. If you use the station monitoring system, you will therefore set the control too conservatively, and get lower loudness.

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But beware the "distorted radio" phenomenon: particularly close to the transmitter, many radios produce excessive distortion all by themselves, and aren't truly reflecting what's being transmitted. If the station monitor (with rolloff) sounds clean but your radio is distorted -- don't trust the radio! This is a traditional problem with managers too -- if the GM's auto radio is distorted, he may think there's something wrong with the station, or your ears. So watch out!

Regardless of the lack of consciously audible artifacts, excessive density can still be subliminally irritating and fatiguing. By backing off the DENSITY control until only 3-5dB of gain reduction is produced in the middle bands of the Six-Band Limiter, a remarkably "open", FM-like sound will be achieved -- albeit with the sacrifice of some loudness. Bear in mind, however, that when the DENSITY control is backed off, the CLIPPING control can be turned up to achieve the same subjective amount of clipping distortion. Properly played off against each other, the DENSITY and CLIPPING controls should lead you to the same loudness on those parts of the program which sound naturally loud before processing; backing off the DENSITY control will reduce the loudness of those parts of the program which are naturally less loud in unprocessed form -- leading to overall improvements in sonic naturalness due to increases in short-term dynamic range.

On Loudness Compromises: You can increase loudness in several ways:

1) MAKE SURE THAT THE AUDIO ENTERING OPTIMOD-AM IS IMMACULATELY CLEAN! This point cannot be stressed too strongly. Clean audio can be processed far more aggressively than distorted audio before objectionable distortion is introduced by the processing. **Appendix K** contains a discussion of ways of cleaning up your audio.
2) Increase the action of the Six-Band Limiter.
3) Increase the amount of clipping (and therefore, distortion) produced by the Multiband Distortion-Cancelled Clipper and Safety Clipper.
4) Operate asymmetrically with +125% modulation (at the expense of distortion).
5) Reduce the amount of equalization at very high and very low frequencies.
6) Place an equalizer in line before OPTIMOD-AM and boost up to 6dB at 1kHz with a "Q" of about 0.7 (two octaves). [Our Model 622A (mono) or 622B (stereo) Parametric Equalizers are ideal for this purpose.]

Traditionally, (5) has been considered very important. However, the sophisticated multiband processing employed in OPTIMOD-AM prevents the amounts of boost available from the built-in Program Equalizer from resulting in serious loudness compromises.

Use of 1kHz equalization (#6 above) is not recommended if you wish to produce a sound competitive with FM, as this EQ will produce the old-fashioned "AM honk", and we do not believe that such a sound is appropriate for the tastes of today's audiences. However, 1kHz EQ is the only way we know to increase loudness above and beyond that achievable by OPTIMOD-AM by itself. 1kHz EQ is particularly effective in increasing the loudness of the low-quality "group-three" radios which are down about -3dB at 2kHz with steep-slope rolloff thereafter. Nevertheless, it should be emphasized that 1kHz EQ is only a "last resort" because it will render the sound louder but far less competitive with FM.

When judging comparative loudness between stations, please note that this will vary according to the frequency response of the radio used, and according to the accuracy with which the radio is tuned. Narrowband radios will usually get very much louder if tuned off center while a highly equalized signal is being received. This means that your auto radio pushbuttons must be carefully adjusted to make meaningful loudness comparisons. In addition, a highly equalized sound (like that produced by OPTIMOD-AM when optimally adjusted) may sound less loud than an unequalized signal on a narrowband radio, yet sound substantially louder on a wider band radio than the same unequalized signal, since the latter radio reproduces more of the frequency range in which the highly-equalized signal concentrates its energy, and to which the ear is most sensitive.

The point is this: loudness is a very complex psychoacoustic phenomenon. It is impossible to say that one station is louder than another unless it is consistently louder on many different receivers and with many different types of program material.

NOTE

Many modulation monitors and/or RF amplifiers will indicate higher modulation than the transmitter is actually producing. This forces the engineer to turn down the volume, and can cost up to 3dB of loudness! It is very important to be sure that your modulation monitor is accurately calibrated using test tones, and that it does not exhibit "overshoot" on program material.

Several newer monitors are specifically designed for accurate pulse response without overshoot. Any of these monitors will enable you to obtain the highest loudness achievable from your specific transmitter and antenna system. If the monitor is used remotely, be sure that the RF amp doesn't overshoot: overshoots in RF amps have been observed to be as high as 3dB also!

SUMMARY The signal going through OPTIMOD-AM passes through five major sections:

1) The BROADBAND AGC, which rides gain;
2) The RECEIVER EQUALIZER, which compensates for receiver rolloffs and optimizes the frequency balance of the airsound;
3) The SIX-BAND LIMITER, which increases density and corrects program material with improper frequency balance or presence problems;
4) The MULTIBAND DISTORTION-CANCELLED CLIPPER, which controls peaks without the usual peak-limiter side effects; and,
5) The TRANSMITTER EQUALIZER, which pre-corrects the output waveform to compensate for overshoot, tilt, and ringing introduced by inaccurate transmitters and antenna systems.

Stereo Matching Of Operating Controls

Once you have settled on a setup which you like, it is desirable to precisely match the stereo operating controls to achieve most stable stereo imaging. The following controls must be stereo-matched:

DENSITY
HF EQ
BASS EQ
BASS TUNING
BASS BANDWIDTH
INPUT ATTEN

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Before you start, match the right-channel ("R") controls to the L controls on the basis on panel calibrations, to provide a starting point.

To perform the matching procedure, both L and R inputs must be driven by an identical mono source. The best way to assure this is to drive the processor from one audio line only, paralleling the L and R inputs.

Matching the INPUT ATTEN controls must be done first. This can be done using the front-panel meter and switching between the L AGC and R AGC positions. Adjust the R INPUT ATTEN until the two meter positions read identically. (You may have to use a tone to see this accurately.)

The other controls may now be matched. One of the best ways of doing this is by nulling the L-R channel by ear. First, the best overall null is achieved with the R DENSITY control. Then the high and low frequencies are trimmed for best null using the HF EQ and various LF equalizer controls.

L-R suitable for this adjustment is available on a test point (a wire loop mounted on the Meter Resistor circuit board) just inside and to the left of the access door. A ground (the lower loop) is also provided there.

If you want to use instruments to null, you must use an audio sweep generator. Switch the MODE switch to PROOF. Driving both L and R inputs in parallel, sweep from 50-10,000Hz. Make sure that the output level of the sweep generator is sufficiently low to avoid clipping in the OPTIMOD-AM circuitry. Drive the horizontal input of an X/Y scope with the ramp output from the sweep generator, and drive the vertical input of the scope from the L-R test point provided on the Meter Resistor circuit board.

First, adjust the R INPUT ATTEN so that the L AGC and R AGC VU meter indications are matched. Making sure that both EQ switches are IN, adjust the R DENSITY control to null the frequency region from 400-1000Hz on the scope. Then adjust the various R equalizer controls to achieve the best null at the high and low frequencies.

CATALOG OF OPERATING OBJECTIVES AND SOLUTIONS

-- TO INCREASE LOUDNESS:

1) Turn the DENSITY control up. This drives the Six-Band Limiter harder.
2) Turn the CLIPPING control up. This provides more clipping, but also increases distortion.
3) Use less BASS EQ.
4) Use 15dB HF EQ instead of 20-22dB.
5) As a last resort, insert an equalizer in the program line. Adjust it to produce a peaking boost of up to 6dB centered at 1kHz with a bandwidth of approximately two octaves ("Q"=0.7).
6) Test the transmitter and antenna to make sure that:
   a) "overshoot", "tilt", "ringing", and "bounce" are insignificant (or that the first three are being properly corrected by the OPTIMOD-AM transmitter equalizer circuit).
   b) OPTIMOD-AM is connected to the transmitter through a circuit path that does not introduce any of the problems in (a) (such as a transformer).
   c) the modulation monitor is correctly calibrated, and does not exhibit ringing or overshoot.
   d) the transmitter is capable of 100% negative and 125% positive modulation without significant distortion.
   e) the antenna and ground systems are intact, and licensed field strengths are being generated at rated antenna current.

-- TO DECREASE DISTORTION:

1) Turn the CLIPPING control down; and/or,
2) Turn the DENSITY control down.
3) Check the transmitter plant as described in (5) above to make sure the transmitter itself isn´t generating distortion.
4) Make sure that the audio before OPTIMOD-AM is immaculately clean. OPTIMOD-AM will reveal flaws that older processing equipment hid behind a curtain of mud.
5) Reduce the amount of high frequency boost. This will make receivers easier to tune, and will make distorted program material less obvious.

-- TO INCREASE "DEFINITION":

1) Advance the HF EQ control.
2) Use less gain reduction in the Six-Band Limiter (by turning the DENSITY control down).
3) Use less clipping by backing off the CLIPPING control.

-- TO MAKE TUNING BROADER AND LESS CRITICAL:

1) Reduce the amount of HF EQ.

-- TO MAKE PROCESSING LESS AUDIBLE WHILE MINIMIZING LOUDNESS LOSS:

1) Use less gain reduction in the Six-Band Limiter (by turning the DENSITY control down).
2) Drive the clippers as hard as possible short of audible distortion (by turning the CLIPPING control up).
3) Reduce the BASS EQ.

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-- TO REDUCE "STRIDENCY" ON WIDEBAND "FLAT-TOP" RADIOS (OR ON ANY RADIO WHEN LESS THAN 12dB HF EQ IS USED):

1) Use the YELLOW or RED equalizer modules (see text).

-- TO INCREASE PRESENCE ON CONVENTIONAL NARROWBAND RADIOS (WHEN MORE THAN 12dB HF EQ IS USED)

1) Use the GREEN (standard) equalizer module.

-- TO MAKE THE BASS MORE "MELLOW":

1) Use center BASS TUNING and broad BASS BANDWIDTH.

-- TO MAKE BASS MORE "PUNCHY":

1) Use center to low BASS TUNING and narrower BASS BANDWIDTH.

-- TO REDUCE NOISE:

1) Use less compression overall.
2) Set the GATE THRESHOLD higher (if the gate is not turning on during pauses).
3) Use Dolby or dbx noise reduction when recording on tape or cart.
4) Use less HF EQ.
5) As a last resort only, use a dynamic noise filter in the program line before OPTIMOD-AM.

-- TO REDUCE SIBILANCE:

1) Use less HF EQ.
2) Use a de-esser (like the Orban 536A) in the microphone channel.

-- TO REDUCE APPARENT NOISE WHEN BROADCASTING LIMITED BANDWIDTH PROGRAM (LIKE TELEPHONE OR SHORTWAVE):

1) Use an external sharp-cutoff lowpass filter on these sources to remove high frequency noise without affecting program content.

-- TO CONTROL LIVE ANNOUNCER SOUND INDEPENDENTLY OF MUSIC

1) Use an Orban 422A Compressor/Limiter/De-Esser on the announce microphone only. Its output may be mixed into the Main Input of the 9100A, or introduced into the 9100A Auxiliary Input. In the latter case, an equalizer like the Orban 622A or 672A may be used before the 422A to brighten up the sound, since the 9100A Auxiliary Input is placed after the 9100A's Program Equalizer.

Part 6:
Proof of Performance

NOTE

The FCC (U.S.A.) has eliminated requirements for periodic Proof-Of-Performance measurements. However, performance standards specified in the FCC Rules must still be met. Many stations will doubtless still wish to make periodic equipment performance measurements. The text below provides the general information which is needed to perform measurements verifying the performance of a transmission system including the 9100A. Instructions for bench-top verification of 9100A performance outside of the transmission system are found in **Appendix D: Field-Audit-Of-Performance.**

In the text below, references to "Proof-Of-Performance" may be read instead as "Equipment Performance Measurements".

Doing a Proof-Of-Performance (assuming the 1982 version of the FCC Rules and Regulations) requires adjusting three switches (four in the stereo version) to put OPTIMOD-AM into the "Proof" mode. Don't operate the switches yet; wait until you come to the **Performing A Proof** section below.

1) TRANSMITTER EQ SWITCH: OUT. This eliminates any high frequency rolloff induced by the H-F SHELF EQ.

NOTE

Except in the most unfavorable cases where the H-F SHELF EQ has been adjusted considerably clockwise from its end stop, the TRANSMITTER EQUALIZATION will ordinarily not disturb the overall frequency response sufficiently to cause problems in a PROOF. In fact, the L-F TILT EQ will tend to correct any bass rolloff problems. In most installations, defeating the transmitter equalizer for a Proof is thus optional.

2) EQUALIZER SWITCH(ES): OUT. This bypasses the Program Equalizer, restoring flat response; and

3) MODE SWITCH: PROOF. This has four functions:

   a) It defeats gain reduction in the Broadband AGC;
   b) It defeats gain reduction in the Six-Band Limiter;
   c) It defeats all clipping circuitry; (**NOTE:** It is still possible to clip amplifiers unintentionally by applying excessive drive levels. Follow level-setting instructions carefully.)
   d) It gates the Broadband AGC, forcing it to slowly move to 10dB G/R ("0" on the G/R meter).

   (To assure that the gain of the Broadband AGC has settled sufficiently to avoid introducing any measurement errors, wait at least two minutes after switching the MODE switch to PROOF before making frequency response measurements.)

OPTIMOD-AM is a very complex system which can be set up in a wide variety of ways. Because of the variations in gain through the system which occur when the INPUT ATTEN and DENSITY controls are adjusted for different tastes, it is not possible to design the system gains such that OPTIMOD-AM performs optimally in the Proof mode for any arbitrary setting of these controls and for any arbitrary adjustment of the main program equalizer. It is therefore necessary to temporarily readjust these controls when a Proof is performed.

In addition, clipping in the 150Hz band is not defeated by switching the MODE switch to PROOF, because clipping in this band ordinarily occurs as a result of VCA clipping, and the VCA headroom cannot be readily extended in a Proof situation. It is therefore necessary to keep the level through the Six-Band limiter low enough to assure that the 150Hz VCA never clips. The following step-by-step instructions assure that this condition is met, and that headroom limitations in other parts of the circuitry are respected.

Please understand that these inconveniences are due entirely to the fact that an AM Proof is a highly artificial test situation which assumes flat frequency response from both station audio chain and receiver, and fails to take into account the fact that contemporary receivers are highly rolled-off. Great engineering effort was expended in assuring that the operating levels inside OPTIMOD-AM yield an optimum combination of low noise and sufficient headroom under normal operating conditions. The complications which may be imposed by a Proof situation do not reflect the realities of how OPTIMOD-AM sounds.

While we could have avoided the whole issue by bypassing the Six-Band Limiter in Proof mode, we feel that this is not only contrary to the spirit of the FCC Rules, but would also tend to permit potential subtle failures within the Six-Band Limiter to go undetected at Proof time -- the only time when they might be detected in many typical operations. A Proof with OPTIMOD-AM in-line is therefore quite rigorous, in that the only circuit elements that are bypassed are simple equalizer circuits -- virtually the entire signal path (including all VCA's) is retained in Proof mode.

PERFORMING A PROOF

The following step-by-step instructions describe a mono Proof. Headroom considerations are no different in stereo operation, and the procedure for stereo Left and Right channel measurements can be deduced by analogy. Techniques unique to Stereophonic Performance Measurements (to measure stereophonic channel separation and stereophonic crosstalk) will be described immediately following the Mono Proof procedure.

1) Connect a 1kHz oscillator through the most commonly used console input. With console gain controls in normal operating positions, adjust the output level of the oscillator until normal operating level (+4 or +8dBm, depending on your standard) is produced at the console output.

2) Turn on the transmitter, and record the percentage modulation of the 1kHz tone as indicated on your modulation monitor. This percentage will be used to restore the setting of the OUTPUT ATTEN control after the Proof is complete. Turn off the transmitter.

3) RECORD ALL OPTIMOD-AM CONTROL SETTINGS, SO THEY CAN BE RESTORED WHEN THE PROOF IS COMPLETE!

4) Switch the OPTIMOD-AM TRANSMITTER EQUALIZER and PROGRAM EQUALIZER out, and switch the MODE switch to PROOF by means of switches provided behind the access door in the OPTIMOD-AM front panel.

5) Adjust the INPUT ATTENUATOR until the VU meter reads approximately "0" VU with the METER FUNCTION switch in L AGC.

6) Switch the METER FUNCTION switch to L+R 12kHz FILTER, and adjust the DENSITY control until the meter reads -6VU. This assures that the 150Hz Band VCA will not be clipped.

7) Turn on the transmitter, and advance the OUTPUT ATTEN appropriate to the transmitter being measured (TX1 or TX2) until 100% negative modulation is achieved. If 100% modulation cannot be achieved due to transmitter limitations, you may use modulation as low as 95%. (With the OUTPUT ATTENUATOR fully clockwise, at least +13dBm into 600 ohms will be available to drive the transmitter. This should be more than sufficient to drive any transmitter to full 100% modulation. However, if a pad is employed between the OPTIMOD-AM output and the transmitter, this pad may have to be bypassed to obtain 100% modulation.)

8) You may now do the Proof in the usual manner. A normally functioning OPTIMOD-AM set up according to our instructions above will typically produce a frequency response ±0.5dB 50-10,000Hz, THD under 0.15% at all frequencies, SMPTE IM distortion (60/7000Hz 4:1) less than 0.2%, and RMS noise approximately 70dB below 100% modulation. THESE FIGURES ARE TYPICAL, ARE PROVIDED FOR REFERENCE ONLY, AND ARE NOT GUARANTEED. Guaranteed specifications are provided in **Appendix L.**

9) When you are finished with the Proof, restore all OPTIMOD-AM setup controls to their settings recorded in (3) above. After this is done, duplicate the conditions described in (2) above, and adjust the appropriate OUTPUT ATTEN to achieve the same percentage modulation as was recorded in (2).

STEREO PROOF CONSIDERATIONS

In general, we apologize for the inconveniences associated with performing an AM Stereo Proof. However, nobody ever said that AM stereo was going to be easy. (Or if they did, they doubtless now wish they hadn't.)

IMPORTANT!

> If the Optional Stereo Enhancement Card #1-S is installed and its Compatibility Control/Stereo Enhancer circuit is strapped IN (by means of Jumpers "C" and "D" on the card), then you must temporarily turn the STEREO ENHANCE control fully counterclockwise before any stereo performance measurements can be made. This control is a stand-up trimmer on the front of Card #1-S. Mark its position in pencil so that it can be restored later.

Before a Stereo Proof is performed, apply 1kHz equally to the L and R console inputs in-phase. Adjust console and/or oscillator attenuators as necessary to produce a reading of 0VU on both L and R console meters. Now record three numbers: L+R, L, and R modulation as indicated on your stereo monitor. These readings will be used after the Proof is completed to restore OPTIMOD-AM to its original setup.

Section 73.1590(b) of the FCC Rules requires making several sets of measurements using Main Channel (L+R) and/or Stereophonic Channel (L-R) modulation. Achieving purest L+R and L-R modulation requires that the channels <u>before</u> the matrix be balanced as well as possible. It is therefore recommended that the Main Channel to Stereophonic Channel Crosstalk test be peformed <u>before</u> other tests requiring L+R and/or L-R modulation. This way, the channels can be balanced during this test, nulling crosstalk as necessary.

Channel balance can be achieved in several ways. For example, the Right Master Gain control on the console could be slightly tweaked to null crosstalk. Alternately, either the OPTIMOD-AM's R INPUT ATTEN <u>or</u> its R DENSITY control could be used to achieve the null.

If the OPTIMOD-AM output amplifiers are strapped in the L/R mode (as opposed to the L+R/L-R mode), then crosstalk will also be affected by the balance between the OPTIMOD-AM L and R OUTPUT ATTEN controls. In this case, we advise nulling crosstalk as read on OPTIMOD-AM's L+R or L-R 12kHz FILTER meter function as described above. Then null crosstalk as read on your stereo monitor by tweaking OPTIMOD-AM's R OUTPUT ATTEN.

Crosstalk which cannot be nulled is usually the result of phase differences between the L and R channels somewhere between the test oscillator and the OPTIMOD-AM input terminals. Phone lines are particularly prone to problems in this area. Because the major portion of the signal-processing circuitry of OPTIMOD-AM is located between the matrix and dematrix circuits (thus processing the signal in L+R/L-R form), crosstalk is unlikely to be caused by OPTIMOD-AM per-se.

Crosstalk occuring before the exciter and/or transmitter will be directly indicated on OPTIMOD-AM's VU meter with the METER FUNCTION switch in the L+R or L-R 12KHz FILTER position. If crosstalk is negligible at this point, but is substantially higher as read on your stereo monitor, then the transmission system after OPTIMOD-AM is suspect.

Separation is much more likely to be affected by OPTIMOD-AM than is crosstalk. This is because channel imbalances between the L+R and L-R signal-processing paths (between the matrix and dematrix, and including the six-band limiter, the multiband distortion-cancelled clipper, the safety clipper, and the various output filters) will translate as loss of separation after dematrixing.

Ordinarily, OPTIMOD-AM is capable better than 30dB separation by itself. This can be verified by direct measurement at the OPTIMOD-AM output terminals, provided its output amplifiers are strapped for L/R output. [Otherwise, they can be temporarily restrapped to make this measurement -- see **Initialization Option #2** in **Installation (Part 3).]**

If the OPTIMOD-AM output amplifiers are strapped for L+R/L-R output, then poor separation can be caused by incorrect adjustment of the L-R OUTPUT ATTEN. Since the L+R OUTPUT ATTEN is ordinarily temporarily readjusted in a Proof situation, the L-R OUTPUT ATTEN will also be readjusted to renull separation.

If adequate crosstalk or separation cannot be obtained, and measurements on OPTIMOD-AM alone indicate that the problem is within the OPTIMOD-AM system, please refer to **Appendix F (Trouble Diagnosis and Correction).**

After an AM Stereo Proof is completed, all OPTIMOD-AM setup controls should be restored to their pre-Proof settings. [Don't forget the STEREO ENHANCE trimmer on the optional Card #1-S (if used).] Restoration of the OUTPUT ATTEN controls should be done with the aid of your stereo monitor.

If the output amplifiers are strapped for L/R operation, restore L and R channel levels by first restoring all setup controls to their normal operating settings. Applying a 1kHz tone equally to the L and R channels, advance the L and R OUTPUT ATTEN controls respectively to secure L and R readings on your stereo monitor identical to those observed before the beginning of the Proof. Final adjustment of the R OUTPUT ATTEN should then be performed by nulling L+R to L-R crosstalk as read on your stereo monitor.

If the OPTIMOD-AM output amplifiers are strapped for L+R/L-R operation, first restore the 1kHz Main Channel reference modulation observed before the beginning of the Proof by adjusting the L+R OUTPUT ATTEN with all setup controls in their normal operating positions. Then adjust the L-R OUTPUT ATTEN to achieve maximum separation when one channel only is driven.

Part 7:
Routine Maintenance

OPTIMOD-AM is a highly stable device which uses solid-state circuitry throughout. Recommended routine maintenance is minimal.

1) Particularly in humid or salt-spray environments, check periodically for corrosion around metal-to-metal contacts such as the audio and control wiring, and those places where the OPTIMOD-AM chassis contacts the rack. Check for loss of grounding due to corrosion or loosening of rack mounting screws.

2) Familiarize yourself with the normal VU meter readings, and with the normal performance of the G/R meters. If any meter reading becomes abnormal, refer to **Trouble Diagnosis (Appendix F).**

3) A good ear will pick up many failures. Familiarize yourself with the "sound" of OPTIMOD-AM as you have set it up, and be sensitive to changes or deteriorations. But if problems arise, please don't blame OPTIMOD-AM by reflex. Refer to **Appendix F** for systematic troubleshooting instructions which will also help you determine if the problem is in OPTIMOD-AM or is elsewhere in the station's equipment.

4) To clean the panel, wash it with a mild household detergent and water. Stronger solvents may damage plastic parts, paint, or the silkscreened lettering.

ROUTINE PERFORMANCE VERIFICATION

There are no definitive, quick instrument tests that can be made to a mono OPTIMOD-AM using ordinary program material. Your ear is the best test instrument.

Dynamic Separation And Crosstalk Test (Stereo Units Only): If you have a stereo OPTIMOD-AM, you can test it differentially with program material by temporarily removing drive to one channel and verifying that the this channel is suppressed by approximately 30dB at the output. If you have strapped the output for L/R operation, separation can be directly observed on the VU meter in the TX1 and/or TX2 L and R positions of the METER FUNCTION SWITCH. (If you have only one transmitter, then, upon initial OPTIMOD-AM installation, you are free to strap the TX2 output amplifiers for L/R operation to facilitate this test.)

IMPORTANT

If you are using the optional Card #1-S, full separation will not be obtained under conditions of single-channel drive if either the 200Hz Highpass Filter or the Single-Channel Limiter/Stereo Enhancer circuit is strapped IN. To make dynamic separation measurements when driving one channel only, you must temporarily strap both of these circuits OUT. (See **Appendix H** for instructions.)

Since most of the signal path processes the signal in sum-and-difference form, a failure in either the sum or the difference path will be indicated by lack of proper separation when the stereo channels are rematrixed into their original L and R form. Thus loss of dynamic separation provides an efficient indication of failure in that part of the system carrying the signal in sum-and-difference form.

(If you are modulating asymmetrically, only left-into-right separation can be expected to achieve the typical -30dB cancellation. Significant highly-distorted right-into-left separation loss is normal for this mode of operation, which has been discouraged elsewhere in this Manual.)

Similarly, if you drive both L and R channels with a mono signal and observe significant main channel-to-subchannel crosstalk, this may indicate a failure in that part of the system carrying the signal in L and R form. (This is directly indicated on the output VU meter if either set of program amplifiers is strapped for L+R/L-R output. However, because the signal is carried in L and R form through a relatively small part of the system, failures here -- resulting in failures in crosstalk cancellation -- are less probable than failures resulting in separation loss. Therefore, if you have a spare set of program amplifiers to devote to diagnostics, it is recommended that the amplifiers be strapped in the L/R mode instead of the L+R/L-R mode.)

Note carefully that this test only indicts OPTIMOD-AM if the loss of separation and/or crosstalk suppression is observed at the OPTIMOD-AM output (as indicated on OPTIMOD-AM's VU meter, or on metering directly connected to OPTIMOD-AM's output). If it is observed at your stereo monitor, problems later in the transmission path could also cause failures in separation or crosstalk cancellation unrelated to OPTIMOD-AM.

When you are finished, be sure to restore Card #1-S (if used) to its normal operating mode.

Pink Noise Test (Stereo or Mono Units): The "standard pink noise test" can be used for quick routine tests of either stereo or mono OPTIMOD-AM operation. This procedure can be performed very quickly, and provides tests of some of the more important OPTIMOD-AM performance parameters. A much more thorough and rigorous procedure is provided in **Field Audit-of-Performance Procedure (Appendix D).**

While this test can be completed in less than one minute, it still requires switching alternate processing on-line temporarily unless you are willing to broadcast pink noise to your audience!

Each time you readjust the OPTIMOD-AM setup controls, apply pink noise to the input (9100A/1), or to both inputs in-phase (9100A/2) after your setup is finished. Adjust the level of the pink noise until the OPTIMOD-AM BROADBAND G/R METER reads "0". Record the reading of each Band G/R meter, and the reading of the VU meter in each position of the METER FUNCTION switch for future reference. These readings provide a standard which can be used to quickly check the operation of the unit in the time that it takes to read the meters. Failure to produce readings close to those observed earlier indicates a failure somewhere within the audio processing circuitry, or, that unauthorized adjustments have been made to the setup controls. (It is important to repeat the reference readings each time that a setup control is readjusted!) If no changes have been made, yet meter readings are substantially different than those expected, refer to **Trouble Diagnosis (Appendix F).**

This concludes **ROUTINE** MAINTENANCE.

Appendix A:
System Description

The purpose of this Appendix is to provide the installing engineer with an overview of system design, to answer questions and deal with uncertainties about various unconventional aspects of the design, and to provide the service technician with a moderately detailed overview of the system.

Each card is numbered. Reference will be made in each section to the number of the card on which the described circuitry is located.

Cards #5, #9, and #10 are installed in the stereo version only (9100A/2).

Card #1-S is an optional card containing a single-channel limiter/stereo enhancer, highpass filters, and lowpass filters.

The paragraphs in **Appendix B (CIRCUIT DESCRIPTION)** that correspond with topics in this Appendix have identical numbers and titles to expedite access to further information on a topic of interest.

REFER TO THE BLOCK DIAGRAM (in **Appendix J**). The **Block Diagram** includes references to relevant paragraphs in **Appendices A** and **B.**

A

1.a) Input Amplifier: [on Cards #4 and #5 (stereo only)]

The audio is applied to an RFI suppression network and pad, the latter strappable for 0 or 20dB attenuation. The RFI-suppressed audio is then applied to a low-noise true instrumentation amplifier, whose "+" and "-" inputs are symmetrical and high impedance. The gain of this amplifier is adjustable from 0.88 to approximately 47 (a 34.5dB range). If this range does not yield the desired amount of gain reduction, the input pad should be restrapped.

In order to avoid distortion due to imperfections in the large-value coupling capacitors that would be necessary, the input is DC-coupled. Therefore, only small amounts of differential DC should be applied to the input. Ordinarily, the input is fed by the output of a transformer or capacitively-coupled amplifier, and no difficulty should arise. Slight amounts of DC offset are eliminated in the 50Hz highpass filter following the input amplifier.

1.b) Input 12kHz Lowpass Filter: [on Cards #4 and #5 (stereo only)]

The output of the input buffer is applied to a fourth-order 12kHz lowpass filter. This filter prevents out-of-band high frequency energy from being processed, minimizing any potential IM between in-band and out-of-band components. This is particularly important if large amounts of high frequency boost are employed in the following Program Equalizer.

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

1.c) Allpass Phase Scrambler: [on Cards #4 and #5 (stereo only)]

Although the overload points of the AM carrier are asymmetrical, current Rules permit only 125% positive modulation: 1.94dB asymmetry. Many voice and musical waveforms are far more asymmetrical than this. It therefore turns out that highest loudness consistent with a given amount of perceived distortion is achieved by phase-shifting asymmetrical input waveforms to make them symmetrical before any processing occurs. (It is our opinion that, given this type of processing, best results are achieved by broadcasting symmetrically. **Asymmetry** in **Part 2** of the manual provides a full discussion.)

Waveforms are made symmetrical by means of a first-order allpass filter (i.e., phase-shifter) in series with a second-order allpass filter in conjunction with the six-band crossover located later in the system. The crossover introduces further phase shift and completes the phase scrambling system.

The phase scrambler is a low "Q" circuit which 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.

1.d) 50Hz Highpass Filter: [on Cards #4 and #5 (stereo only)]

The output of the phase scrambler is applied to a third-order elliptical highpass filter with 50Hz cutoff frequency (0.5dB down), 0.5dB ripple, and a deep notch at 25Hz (to deal with automation cuetones which may have leaked through other filtering). This filter is not conveniently bypassable. It was felt that the advantages of this filter [i.e., elimination of modulation-wasting subsonic energy from rumble and other sources, elimination of subsonic energy's introducing distortion by modulating the compressor control voltages, prevention of distortion introduction in transmitters (which could be exaggerated by the Transmitter Equalizer), and prevention of loudness loss due to the inability of most receivers to reproduce audio below 50Hz] merited the filter's inclusion as a standard part of the system.

2) Broadband AGC (General)

The Broadband AGC is a feedback compressor whose attack and release time constants can be chosen by the operator to be either SINGLE (200ms attack; 3dB/second release) or MULTI (program-controlled).

The main audio path through the Broadband Compressor consists of a high-quality VCA capable of less than 0.05% harmonic or IM distortion and an overload-to-noise ratio of approximately 90dB. The output of this VCA is applied to a control circuit which senses the average output level of the VCA. If the output attempts to rise above a predetermined threshold, the control circuit increases its gain-control output signal, thus controlling average levels out of the VCA by feedback.

2.a) Voltage-Controlled Amplifier (VCA) Operation: [on Cards #2 and #3]

The voltage-controlled gain block used throughout OPTIMOD-AM is a proprietary Class-A VCA which operates as a two-quadrant analog divider 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, and the output of the second block is a distortion-corrected current which is transformed into the desired gain-controlled voltage by means of an opamp current-to-voltage converter.

2.b) AGC Control Circuitry: [on Card #6]

In a stereo unit, the outputs of the left and right AGC's are summed into a precision rectifier, assuring that the rectifier responds to the sum of the channels (L+R). To assure identical timing characteristics in both the mono and the stereo units, a "mono" jumper forces both the L and R rectifier inputs to be driven from the output of the L (mono) VCA when operating in mono mode.

The output of the rectifier feeds a proprietary timing module which takes the rectified L+R and computes a control voltage for the VCA. The output of this module is in dB-linear form, and drives a linear-scale AGC G/R meter.

Release is slowed and redirected toward 10dB G/R ("0" on the BROADBAND AGC G/R meter) if the input signal falls below a level set by the user-adjustable GATE THRESHOLD control. 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 a front-panel GATE LED.

3.a) Bass Equalizer: [on Cards #4 and #5 (stereo only)]

The bass equalizer is a "quasi-parametric" configuration offering control over frequency of peak equalization (70-110Hz), amount of equalization (0-6dB), and bandwidth of equalization (Q=0.3 to 1.4). Adjustment of frequency or amount of boost changes the fractional bandwidth. Otherwise, the controls are non-interacting. The equalizer employs a dual-amplifier quasi-parametric bandpass resonator whose output is summed with the unequalized signal in the main amplifier for the high frequency equalizer.

3.b) High Frequency Equalizer: [on Cards #4 and #5 (stereo only)]

The high frequency equalizer creates an 18dB/octave shelving boost to accurately equalize the "average" AM radio out to a frequency determined by the setting of the HF EQ control. The equalization is realized by a special filter which introduces a controlled amount of positive feedback around an opamp. The amount of positive feedback determines 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 the family of curves produced by the High Frequency Equalizer to the needs of your target audience.

(NOTE: Patents are pending on the circuit realization of the equalizer.)

4) Matrix: [on Card #5]

The matrix is found in stereo units only. It takes the L and R signals from the program equalizer and produces sum-and-difference (L+R and L-R) signals to drive the subsequent circuitry.

The output of the L program equalizer (on Card #4) is brought out to Card #5 and applied to the matrix. The L+R matrix output is then returned to Card #4. In mono units, the matrix is bypassed by means of a jumper on Card #4.

The card pinouts are arranged to permit swapping Cards #4 and #5 for trouble diagnosis in stereo units. See **Trouble Diagnosis (Appendix F).**

5) Six-Band Limiter And Distortion-Cancelled Multiband Clipper (General)

The six-band limiter is so intimately connected with the multiband clipper that the two systems should really be considered as one.

The signal is first divided into six frequency bands by a pre-compressor crossover. Each crossover filter then drives its own compressor/limiter. The output of each compressor/limiter drives a clipper followed by a post-compressor filter. (The characteristics of the pre- and post-compressor filters are such that the final summation of the bands can be made to be very flat -- better than $\pm$0.5dB.)

These 6dB/octave post-compressor filters following the clippers provide first-order reduction of clipper-induced distortion. 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 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 1.8kHz lowpass filter.

Meanwhile, the clipped, filtered sum of all of the bands is passed through a phase-corrected 12kHz filter whose delay matches that of the 1.8kHz lowpass filter. The outputs of the 12kHz and 1.8kHz filters are summed, sharply cancelling clipper-induced distortion below 1.8kHz (the average "flat" passband of an AM radio.) This provides radically improved distortion reduction compared to simple first-order filtering after the clippers alone. (The effective selectivity is about 36dB/octave.) The cancellation is particularly effective in eliminating the characteristic "ffff" sound of heavily-clipped sibilance, ordinarily induced because of the radical amounts of difference-frequency IM caused by heavy clipping.

It should be noted that it is normal for sinewaves to modulate less than 100% when applied to OPTIMOD-AM in its normal OPERATE mode. There are two principal reasons for this:

1) Some headroom is left between the threshold of the Multband Distortion-Cancelled Clipper and the threshold of the subsequent safety clipper in order to accomodate the distortion corrector signal. With sinewaves, no distortion corrector signal is produced. Thus, the headroom is not used, and full 100% modulation does not occur.

2) Sinewaves have a very low peak-to-average ratio and high loudness potential compared to program material of identical peak levels. The audio processing, in order to maintain natural sound quality, pushes sinewaves 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 sinewaves tends to sound somewhat unnatural because this psychoacoustic factor has not been accounted for.

(NOTE: This system is protected by U.S. Patent #4,412,100.)

5.a) Pre-Compressor Crossovers: [on Cards #4 and #5 (stereo only)]

The crossovers are realized as follows:

1) 150Hz lowpass	Second-order 420Hz lowpass filter cascaded with second-order 150Hz lowpass filter
2) 420Hz bandpass	Second-order 420Hz lowpass filter cascaded with third-order 420Hz highpass filter
3) 700Hz bandpass	Two second-order stagger-tuned bandpass filters cascaded
4) 1.6kHz bandpass	as above
5) 3.7kHz bandpass	as above
6) 6.2kHz highpass	Second-order 6.2kHz highpass filter

Bands 3-6 are fed from a first-order allpass filter which provides phase correction for the crossover summation.

5.b) Six-Band Limiter VCA's: [Bands 1,3,5 on Card #2; Bands 2,4,6 on Card #3]

The VCA's in bands 1-5 have a potential gain reduction range of 25dB. To accomodate the extreme HF preemphasis available, the available G/R range of band #6 is 30dB.

Both mono and stereo OPTIMOD-AM's are fully equipped with factory-aligned stereo VCA's. In mono units, certain IC's have been removed to prevent potential oscillation of the VCA's due to their inputs being unterminated. These IC's are reinstalled at the time of stereo conversion, and are included in the stereo conversion package.

For a discussion of the operation of the VCA's, the reader is referred to paragraph (2.a), above.

5.c) Six-Band Limiter Control Circuitry: [on Card #6]

The output of each band VCA feeds a voltage divider which, in turn, feeds a dual comparator IC. If the output of the voltage divider exceeds a positive or negative threshold set by the CLIPPING control (0.5 to 1.0V), the comparator will produce an output pulse which is smoothed by the timing module, producing a control voltage which reduces the gain of the VCA. The drive to the clippers following the compressors and preemphasis/high-frequency limiters is thus determined by the setting of the CLIPPING control, which simultaneously adjusts all comparator thresholds (and thus the average VCA output level).

This timing circuitry is proprietary, and is located within sealed modules. It performs the following functions:

1) A peak limiting function with very fast recovery time for transient material;

2) A slower compression function whose recovery time is a function of gain reduction; and,

3) A recovery-delay function which provides extra 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. These drive exponential converters which provide control-current outputs for their respective VCA's.

5.d) **Post-Compressor Crossover, Clippers, and Distortion-Cancellation System:** [on Cards #7 and #10 (stereo only)]

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 IM 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 1.8kHz. This rolloff 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 cancelled below 1.8kHz by means of a feedforward distortion-cancelling sidechain (U.S. patent #4,208,548). 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 highpass; 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-cancel summing amp. If no clipping occurs, the outputs of the inverting and non-inverting filters will cancel, and no output will be produced by the distortion-cancel summing amp. If clipping does occur, then the output of the distortion-cancelled summing amp will represent the difference between the clipper's input and output as filtered by the inverting filter: i.e., the distortion added by the clipper, as filtered through the inverting filter.

Since the upper four bands are all handled by the distortion-cancel 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-cancel filter: a 1.8kHz lowpass filter with constant delay.

Meanwhile, the outputs of the inverting filters alone (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 lowpass filter.

The outputs of the 12kHz filter and 1.8kHz filter are summed. Considering for a moment the case where only one band is passing signal, the clipper-induced distortion component contributed by this band to the 1.8kHz filter's output is equal to, and out-of-phase with, the same distortion component in the 12kHz filter's output. Thus, this distortion component is cancelled by better than 30dB within the 1.8kHz bandwidth of the distortion-cancel filter. Because both the 12kHz and 1.8kHz filters are linear, as is the summation process, superposition holds, and the distortion component in each of the four top bands is cancelled even when more than one band is active.

The two low frequency bands are not treated by the distortion-cancellation sidechain because the objectionable distortion in this case is not IM, but rather harmonic distortion above the frequency range of the bands in question. Accordingly, simple lowpass filtering of the clipped signal is employed for distortion reduction.

Clipping in the 150Hz band is achieved by forcing the VCA to clip slightly above the threshold of limiting, removing overshoots. This clipped signal is applied to a pair of cascaded 6dB/octave lowpass filters before it is summed with the rest of the 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 through the second lowpass filter to the band summation amplifier. The clipper thus clips the sum of the 420Hz band and the clipped, filtered 150Hz band. This low-frequency sum is constrained by the clipper to be several dB below 100% modulation, preventing excessive IM between the low frequencies and high frequencies in the final safety clipper.

6) Optional Stereo Enhancement Card: [Card #1-S]

Card #1-S is divided into three "subsystems". In order of signal flow, these are:

1. 200Hz L-R Highpass/200Hz L+R Allpass Filter (stereo);
2. 5kHz Lowpass Filter (L+R and L-R); and,
3. Single-Channel Limiter/Stereo Enhancer

The application of Card #1-S is described in **AM STEREO** in **Part 2** of this manual. Installation and adjustment of the card are described in **Appendix H** of this manual. A detailed circuit description is provided in **Appendix B** of this manual.

7) Output Section (General)

The output section provides final peak limiting and interfaces OPTIMOD-AM with the transmitter. It consists of a hard safety clipper, a non-overshooting supersonic lowpass filter, a transmitter equalizer, a dematrix circuit (stereo units only), and a set of active balanced Line Amplifiers.

The circuit path can be optionally broken twice before the input of the output section. The first break permits insertion of the optional filter card (see **6** immediately above). The second break permits moving the dematrix circuit. This circuit is ordinarily located between the output of the transmitter equalizer and the input of the Line Amplifiers. If certain jumpers are moved (see **Installation of the Accessory Port: Appendix I**), the dematrix can be used to process the signal sent to the Accessory Port, such that it is in L/R form instead of L+R/L-R form.

If the matrix is so diverted, it is unavailable for use in its standard location and the main output of OPTIMOD-AM must therefore be in whatever form (L/R or L+R/L-R) that the exciter provides as a return to the Accessory Port.

These various breaks in the circuit path are physically realized by means of jumpers which are positioned according to instructions in the **Initialization Options** sections of **Installation (Part 3).**

7.a) Safety Clipper: [on Cards #7 and #10 (stereo only)]

The safety clipper provides the final peak limiting function for the processing. It is an extremely "hard" clipper, realized with biased Schottky diodes. The "hard" characteristic provides substantially less IM distortion than the "soft" clippers commonly used for this function in other processing equipment. It is particularly important not to add further clipping (particularly "soft" clipping) to the system after the OPTIMOD-AM output as this will cause the sound to become less defined and much more fatiguing.

The clipper can be operated with as much as 100%/150% asymmetry. For reasons discussed in **Asymmetry** under **Various Application Notes (Part 2),** we recommend symmetrical operation for cleanest sound, particularly in stereo.

The safety clipper is buffered by an amplifier. In the L-R path only, the gain of this amplifier is adjustable to match the L+R and L-R channel gains as closely as possible, maximizing dynamic separation.

7.b) Supersonic Lowpass Filter: [on Card #7 and #10 (stereo only)]

6dB of clipping ordinarily occurs in the safety clipper when processing highly preemphasized program material. This is sufficient to cause excessive out-of-band energy unless the sharp "edges" caused by the clipping process are filtered. Therefore, a supersonic third-order non-overshooting lowpass filter is included in the system 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.

Spectrum analysis in our laboratory has confirmed that this filter results in meeting all FCC (U.S.A.) occupied bandwidth requirements with at least 6dB of safety margin with the most severe program material we could find (certain "disco singles"). This is true only in the monophonic and linear stereo (i.e., Harris) cases; the non-linear AM stereo systems may add sufficient high frequency energy to the radiated signal to violate occupied bandwidth rules unless the optional 5kHz L-R lowpass filter is used. [See **AM Stereo** in **Various Application Notes (Part 2)** for a further discussion.]

If you are using a non-linear stereo system, it is highly recommended that your occupied bandwidth be examined with an RF spectrum analyzer to assure that it meets all FCC (U.S.A.) requirements.

7.c) Transmitter Equalizer and Logic: [on Cards #8 and #9 (stereo only)]

The transmitter equalizer consists of three stages. The first provides a 2.5dB shelving rolloff whose initial frequency of operation is adjustable from approximately 500Hz to beyond the passband of the OPTIMOD-AM system. This shelving rolloff will reduce or eliminate high frequency rolloff in a vast majority of antenna/transmitter systems with such difficulty. It is created differentially by subtracting the output of an adjustable highpass filter from the main signal.

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

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

The transmitter equalizer can be activated or defeated by means of a single TX EQ IN/OUT switch which controls both L+R and L-R channels.

The transmitter equalizer may not be usable with certain AM stereo systems. See **AM Stereo** in **Various Application Notes (Part 2).**

The amount of correction of each transmitter equalizer section can be preset by means of four controls. Only one control can be active at any one time. Which control is active is determined by means of JFET switches, controlled by the DAY/NIGHT; TX1/TX2 logic. The memory for the TX1/TX2 mode, and for the DAY/NIGHT mode is provided by a pair of bistable flipflops, each realized as two crosscoupled CMOS NAND gates. The state of these flipflops can be switched by means of local momentary switches or by optically-isolated remote control.

The state of the two flipflops represents a two-digit binary word which is decoded into one of four lines by means of a binary decoder, assuring that only one control within a given transmitter equalizer section will be active.

A

7.d) Dematrix: [stereo only: on Card #9]

The dematrix transforms the L+R and L-R back into L and R. It consists, as does the original matrix, 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 dematrix is available to feed the Line Amplifiers. By choosing the position of jumpers, the Line Amplifier can also be fed by L+R and L-R (the inputs to the dematrix). Indeed, one set of Line Amplifiers could be fed L and R while the other set was fed L+R and L-R.

A further set of jumpers permits diverting the dematrix so that it can be used before the Accessory Port to provide L and R to the stereo exciter. In this case, because the dematrix is unavailable at its ordinarily circuit location, the Line Amplifiers must be fed by the same signal that is fed back into the Accessory Port by the exciter. This signal is processed by the Safety Clipper, Supersonic Lowpass Filter, and optionally, the Transmitter Equalizer before being applied to the Line Amplifiers.

Settings for the various jumpers are described in **Initialization Options** in **Installation (Part 3).**

Because the dematrix inverts the absolute polarity of the signal, inserting it into the signal path will change the polarity of the signal corresponding to positive modulation. (This is only important if you are operating asymmetrically in stereo -- a mode not recommended because it introduces asymmetrical non-linear crosstalk between L and R.)

The OPTIMOD-AM output has been configured so that a positive-going signal at the (+) output terminal normally corresponds to positive modulation (L+R/L-R or mono modes). When the dematrix is inserted (L/R mode), a negative-going signal corresponds to positive modulation at the same point: the dematrix inverts the polarity.

Similarly, when the dematrix is diverted for use before the Accessory Port (as described above), it is important to connect, in an overall-inverting manner, that part of the exciter feeding signal back into the Accessory Port (within the limitations introduced by the exciter's phase-shift networks, which will vary the polarity at certain frequencies). When this is done, the inversion produced by the dematrix will be re-inverted by the exciter, yielding an overall non-inverting characteristic. This is important because asymmetrical operation of OPTIMOD-AM operates both the multiband clippers and the safety clipper asymmetrically, and the asymmetry as seen at the safety clipper (after the exciter) must have the same polarity as the asymmetry seen at the multiband clippers (before the exciter).

7.e) Balanced Line Amplifiers: [on Card #8 and #9 (stereo only)]

The line amplifiers are totally straightforward. They consists of a pair of inverting opamps. These are 5532 devices 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.

8) Power Supplies:

Primary power for the OPTIMOD-AM circuitry comes from a highly regulated ±15 volt power supply. The main supply is +15 volts. This is controlled by means of a 723C IC regulator with current-boosted output, current limiting, and overvoltage protection using a zener diode and fast-blo fuse.

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

The 711C comparators used in the Six-Band Limiter require +12/-6 volt sources. These are developed by locally dropping the main +15 volt supply through three forward-biased silicon diode junctions (to create the +12), and by means of a zener diode in series with the -15 (to create the -6).

Bias sources are also required for the diode clippers in the audio processing. There are two such sources; the first creates approximately ±1.8 volts, while the second creates ±4.1 volts (both for Cards #7 and #10). Both sources employ a pair of opamps. The first is a unity-gain voltage-follower whose input is a temperature-compensated voltage created by a resistor/diode network; the second is a unity-gain inverter which creates the complementary negative voltage. An additional current can be summed into the inverter by means of the POS PEAK THRESH control to create asymmetrical bias on the clipper diodes, thus producing asymmetrical modulation.

A similar supply on Card #6 is adjustable from ±0.5 to ±1.0V by means of the CLIPPING control. It supplies a reference for all of the 711C comparators to determine the threshold of limiting in the Six-Band Limiter.

This concludes **APPENDIX A (SYSTEM DESCRIPTION).**

Appendix B:
Circuit Description

The following section provides an extremely detailed description of the circuitry used in OPTIMOD-AM, at the component level.

It is essential to read the **System Description (Appendix A)** first, and to consult the block diagram in **Appendix J.** Referring to the appropriate schematics and parts locator drawings in **Appendix J** will help you follow the text and will aid component-level troubleshooting.

The paragraphs in **Appendix A (SYSTEM DESCRIPTION)** that correspond with topics in this Appendix have identical numbers and titles to expedite access to further information on a topic of interest. The **Block Diagram** includes references to relevant paragraphs in **Appendices A** and **B.**

In those cases where the circuitry is duplicated for stereo, only the left channel or L+R channel circuitry and component reference designators (depending on whether the signal is in L/R or L+R/L-R form at that point in the circuit) will be discussed.

1.a) Input Amplifier: [on Cards #4 and #5 (stereo only)]

The input is applied to the RF filter chamber, and there encounters an RF filter and 10K bridging pad R1, R4. Strapping R2 and R3 into the pad introduces 20dB loss, which is the normal condition of the pad.

The output of the pad is connected to a low-noise true instrumentation amplifier consisting of 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 GAIN 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, and the common mode component of the output is nulled by means of differential amplifier IC13A and associated resistors.

NOTE:

Nearby lightning strikes may induce sufficient energy into OPTIMOD-AM's audio input wiring to pass through the RFI protective networks and destroy IC14. If OPTIMOD-AM is installed in a lightning-prone location, it is advisable to keep spare IC's in stock. Installation of Varistors or other protective devices between each side of the audio input line and earth may help prevent such problems. (IC14 is socketed, and is thus easily replaced.)

1.b) Input 12kHz Lowpass Filter: [on Cards #4 and #5 (stereo only)]

The 12kHz input lowpass 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.

The type of active filter section employed here is described in any modern text on active filter design (see for example--Wong and Ott: Function Circuits. McGraw-Hill, New York, 1976, Chapter 6).

As in any filter, the resistors and capacitors within each section interact. The two sections, however, do not interact with each other: the frequency response of the filter is the dB sum of the frequency responses of the two sections. Accordingly, the best way to troubleshoot such a filter is to first check the opamp. If the opamp is good, use an accurate impedance bridge to test each of the precision resistors and capacitors in turn until the bad component is found. (Capacitors tend to be less reliable than resistors, and should be checked first.) Because the passive components are highly understressed, failures are improbable.

1.c) Allpass Phase Scrambler: [on Cards #4 and #5 (stereo only)]

The allpass 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 degrees as a function of frequency. It consists of IC12B, R19, R20, R21, C6, C7.

The second section's frequency response varies from 0 to 360 degrees 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 assure flat frequency response.

For troubleshooting tips, refer to paragraph **1.b** above.

1.d) 50Hz Highpass Filter: [on Cards #4 and #5 (stereo only)]

The 50Hz highpass filter is a third-order elliptical filter. The first-order section is realized by C10 working into the input resistance of the following Broadband AGC VCA on Card #2.

The second-order section (which realizes the 25Hz notch), is realized with IC11B, R27, R28, R29, R30, R31, R32, C8, C9. In order 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 rolloff provided by the first section.

For troubleshooting hints, see paragraph **1.b.**

2.a) Voltage-Controlled Amplifier (VCA) Operation: [on Cards #2 and #3]

NOTE

> This section contains a general description of the Voltage-Controlled Amplifier circuitry used throughout OPTIMOD-AM. The Broadband AGC VCA (on Card #2) will be specifically described.

The basic operation of our VCA depends on a precisely-matched pair of gain-control blocks with differential voltage inputs and current-source outputs. The gain of each block is controlled by means of a control current.

If used alone, one such gain-control block 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 predistorted output of IC17. To provide more detail: 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 predistorted 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 predistorted voltage is also connected to the input of IC18B. Thus the output of IC18B is 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. Thus if the control current is applied to the control port of IC18A (through R7), then the VCA behaves like a two-quadrant analog divider.

A fixed current is applied to the control port of IC18B through R10 to fix the gain of IC18B. R10 is fed by a +1.2V source common to all VCA's on a card: R16, CR3, CR4. The diodes provide temperature compensation.

Second-harmonic distortion is introduced by differential offsets in either IC18A or IC18B. This distortion is cancelled by applying a nulling voltage directly to the input of IC18B by means of 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 a correct DC offset is applied to the VCA input, then this equivalent DC multiplication can be nulled to zero and the "thumps" eliminated. Such an adjustable DC offset is provided by R4C, R2.

R3, C1 are frequency-compensation components to prevent the VCA from oscillating supersonically.

The basic current-controlled gain in the compressor/limiter is inversely proportional to the control current. This must be transformed into a gain which is proportional to a control voltage in dB. This is done in the exponential current converter consisting of IC21A and associated components.

IC11A, IC11E, and associated components form a log/antilog multiplier which multiplies the current flowing in 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 VCA's on a given card are located within monolithic array IC11. One transistor within this array (IC11E) is dedicated to providing a reference for all of the exponential converters. The emitters of all the exponential converter transistors are connected to this common source.

This reference (approximately -0.6V) is produced by forcing a constant current through IC11E. The voltage across R115 is held at 15 volts by the feedback action of IC10A, determining the current through IC11E and thus its base-to-emitter voltage. C25 prevents IC10A from oscillating, and CR7 protects IC11E from a reverse bias latchup condition which could otherwise zener IC11E's base-emitter junction and permanently damage it.

The output current of the log/antilog multiplier appears on the collector of IC11A. It is the wrong polarity and level to correctly drive the control-current port of IC18A. It is therefore applied to a current inverter IC21A, Q1, R15, R16, C5. This circuit has a gain of 6.66x, and operates as follows:

A voltage proportional to the current output of IC11A is developed across R16 because of the feedback action of IC21A. (C5 stabilizes IC21A against oscillations.) Feedback forces IC21A's (-) and (+) inputs to be at the same voltage. Thus, the same voltage which appears across R16 also appears across R15, and current flows in 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.

The base of Q1 is grounded; its emitter therefore sits at +0.6V. This forces both (+) and (-) inputs of IC21A to also sit at +0.6V, and assures correct bias voltage for IC11A's collector.

CR1 protects Q1 from reverse base-emitter voltage which could otherwise cause junction breakdown and latchup of the entire current-inverter circuit.

2.b) AGC Control Circuitry: [on Card #6]

The sum of the left and right Broadband VCA outputs is applied to a full-wave precision rectifier IC4A and associated components. This circuit is conventional, and operates by adding twice the inverted output of a precision half-wave rectifier to its input.

The rectifier output is applied to a proprietary timing module which integrates the rectifier output and provides a control voltage to drive the Broadband AGC VCA's on Card #2.

The threshold of compression is determined by R61 for the slow attack circuitry (used in both "single" and "multi" time constant modes); the threshold for the fast attack circuitry (used in "multi" only) is determined by R63.

In PROOF mode, the proof bus is forced to +15V. (In OPERATE mode, the bus floats). In PROOF mode, 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. CR6 and CR7 isolate the circuitry from the proof bus when it is in OPERATE mode.

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 and its high frequency response is rolled-off by C8. Both rolloffs are 6dB/octave.

The output of IC12A is applied to peak detector CR1, C10, R45. 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, lighting the GATE LED and turning off the gating 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.

Under non-gated conditions, the release time is determined by R50.

When the unit is in PROOF mode, the PROOF bus goes to +15 volts, forcing the input of IC12B positive and its output negative, thus gating the Broadband AGC and forcing it to 10dB G/R.

3.a) Low-Frequency Equalizer: [on Cards #4 and #5 (stereo only)]

The low frequency equalizer employs a second-order "quasi-parametric" bandpass resonator IC9, R35, R36, R37, R38, R39, R40, R41, R43, R44, C11, C12. The resonator's output appears at the output of IC9A. To create peak boost, it is summed with the input signal of the resonator through R42 and R34 respectively. The amount of equalization is determined by the resonator's input attenuator R35. 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.

The operation of the resonator can only be justified mathematically and will not be further discussed. Because of the multiple feedback loops, repair of the resonator is usually a cut-and-try affair in which IC9 is first checked. Then each of the passive components is tested with an impedance bridge. Passive component failure is extremely unlikely due to the lack of stress on the passive components.

E

3.b) High Frequency Equalizer: [on Cards #4 and #5 (stereo only)]

High frequency equalization is created 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 retuning the equalizer (by retrofitting a revised, pre-tested module) should the average AM radio frequency response change significantly in the future.

The amount of HF EQ is adjusted by setting the amount of positive feedback by means of HF EQ control R46.

Because the equalizer employs positive feedback, it is quite sensitive to shifts in component values and gain. If the equalizer's frequency response shifts, yet IC5A is OK and still passes signal, first suspect IC9A. When operating properly, this opamp provides a low-impedance termination for R42. If the opamp fails, R42 will become unterminated, changing the closed-loop gain of IC5A and therefore the amount of frequency-selective positive feedback around it. (Failure of IC9A will also cause failure of the Bass EQ.)

If failure of IC9A is not the problem, check C13, C14, C15.

Module A1 contains only elements which have proven to be extremely stable and reliable, so failures within this module are extremely improbable. Only if all the other possibilities are eliminated should A1 be replaced.

4) Matrix: [on Card #5 (stereo only)]

The sum signal is created by inverting summing amplifier IC10A, R50, R51, R52. The output of this amplifier is mathematically -(L+R).

The difference signal is created by differential amplifier IC10B, R53, R54, R55, R56. The output of this amplifier is mathematically -(L-R). Thus the sum and difference signals are both inverted as they pass through the rest of the circuitry. Because the phase scrambler has already made the audio symmetrical, this inversion is inconsequential.

The rather obscure routing of signals back and forth between Cards #4 and #5 is designed to permit Cards #4 and #5 to be swapped for troubleshooting purposes as described in **Appendix F.**

5.a) Pre-Compressor Crossovers: [on Cards #4 and #5 (stereo only)]

Little need be said about these filters which has not been stated already in **Appendix A.** All filters are built with second-order sections of the type found in any modern text on active filter design (see for example--Wong and Ott: Function Circuits. McGraw-Hill, New York, 1976, chapter 6). Some filters are of the "multiple feedback" type, and are basically negative-feedback filters. Others are of the "Sallen and Key" type, and are positive feedback filters. The two types are mixed as necessary to achieve desired inverting (negative feedback) or non-inverting (positive feedback) responses.

5.b) Six-Band Limiter VCA's: [Bands 1,3,5 on Card #2; Bands 2,4,6 on card #3]

Except for the fact that a few frequency compensation components are omitted and different-type IC opamps are used, these VCA's are identical to the Broadband AGC VCA's. The reader is referred to **2.a** above.

5.c) Six-Band Limiter Control Circuitry: [on Card #6]

Except for component values, the control circuits for all six bands are identical. We will discuss the control circuit for Band 1 (150Hz) in detail.

The output of the Band 1 VCA is applied to voltage divider R1, R2 which protects IC2, a 711 dual comparator, from being driven beyond its ratings. IC2 produces a positive-going pulse of approximately +4.5V if the output of voltage divider R1, R2 exceeds the comparator threshold voltage generated by IC8 and associated circuitry. The threshold of limiting is thus determined by two factors: (1) the loss in voltage divider R1, R2 (the more loss, the higher the voltage at the VCA output before IC2 turns on); and, (2) the threshold voltage applied to IC2. This voltage is varied from ±0.5 to ±1.0V by means of CLIPPING control R65, varying the threshold of limiting (and thus the average output level of the band VCA's) by feedback.

The output of IC2 is applied to a unity-gain inverter and level shifter Q1, R3, R4. The waveform at the collector of Q1 consists of pulses which go 4.5V below the +12V collector supply voltage. These pulses develop approximately 4V across R5, the emitter resistor of Q2. The current which flows through R5 is essentially identical to that flowing from the collector of Q2 into the timing module. The value of R5 scales this current, determining the attack time.

The timing module integrates this 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).

5.d) Post-Compressor Crossover, Clippers, and Distortion-Cancellation System: [on Cards #7 and #10 (stereo only)]

(The reader is strongly advised to read the discussion of this part of the circuitry in **Appendix A** before embarking on the following description, as the two descriptions complement each other.)

We will use Band 5 (3.7kHz) as a typical "high frequency" band for purposes of discussion.

The output of the band VCA is applied to 6dB/octave highpass filter R22, R24, C13. Clipper diodes CR7, CR8 are embedded between R22 and R24 and clip the output of the band VCA before it is applied to the highpass filter.

The clipped signal is also lowpass-filtered by the feedback action of R25, C14 in association with IC2A, which inverts the signal. Thus the output of IC2A is the clipped signal, as passed through a bandpass filter (highpass+lowpass) with 6dB/octave skirts.

The output of the band 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 passive filter (which is non-inverting) is summed through R27 with the output of IC2A through R29 onto the distortion-cancel summing amp IC6A's summing bus. When clippers CR7 and CR8 are non-conductive, total cancellation occurs (within the limitation of component tolerances), and no signal appears on the summing bus.

When the clippers conduct, all signal is cancelled except for the distortion added by the clipping process, as filtered by IC2A and associated components.

The output of IC2A is also summed through R28 onto the band summation amplifier IC3A's summing bus.

To preserve the proper asymmetry in all bands when the multiband 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 the Band 1 VCA is lowpass filtered by R1, R3, C1, and then mixed with the output of Band 2 through R2. The sum is clipped by CR1, CR2, and lowpass filtered again through R4, R5, C2 before being applied to the (+) input of band summation amplifier IC3A.

The output of IC3A feeds a passive 5th-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. (A complementary shelf produced by IC9B restores flat response later.)

The output of IC3B feeds a pair of second-order allpass filters IC4A, IC4B, and associated components. Each of these circuits has a flat magnitude response but a phase response which varies with frequency. The phase response is designed to equalize the phase response of the 12kHz lowpass filter, producing approximately constant time delay from 0 to 12kHz. This minimizes overshoots in the 12kHz filter.

Meanwhile, the output of distortion-cancel summing amp IC6A feeds a 1.8kHz lowpass filter R66, R67, R68, L3, C35, A1 whose amplitude and phase response match that of the passive 12kHz lowpass filter, shelving filter IC3B, and phase corrector IC4 through 1.8kHz. The output of the 1.8kHz distortion-cancel lowpass 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-cancelled sum of the six bands. Its bandwidth is limited to 12kHz. It contains substantial overshoots which are ordinarily removed in the following safety clipper.

Jumpers provide the ability to break the circuit path before the safety clipper in order to (a) insert the 5kHz lowpass filter(s) located on (optional) Card #1; and/or, (b) divert the signal to the optional Accessory Port (see **Installation of the Accessory Port, Appendix I)** so that the signal can be fed through the early stages of an AM Stereo exciter (which may upset peak levels due to the inclusion of phase shift networks), and then be returned to OPTIMOD-AM for final peak limiting before being applied to the final stages of the exciter.

In stereo units, the signal at the output of IC9B is in L+R/L-R form. There are jumpers on Card #9 (stereo only) which permit placing the dematrix (on Card #9) before the Accessory Port so that the exciter can be fed audio in L/R form.

6) Stereo Enhancement Card: [Card #1-S]

Card #1-S is divided into three "subsystems". In order of signal flow, these are:

1. 200Hz L-R Highpass/200Hz L+R Allpass Filter (stereo);
2. 5kHz Lowpass Filter (L+R and L-R); and,
3. Single-Channel Limiter/Stereo Enhancer.

These will be described below in order of signal flow.

6.a) 200Hz L-R Highpass/200Hz L+R Allpass Filter: [on Card #1-S]

The signal enters the card in sum-and-difference (L+R/L-R) form. At this point, it has been processed by the Six-Band Limiter and Multiband Distortion-Cancelled Clipper, but not by the safety clipper.

The L+R enters a third-order allpass 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 highpass filter in the L-R channel above 190Hz.

The highpass filter consists of IC2 and associated components. It is a fifth-order filter with a deep notch at 104.5Hz and unity gain. It nominally 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 allpass and highpass filters are non-inverting at high frequencies. (At frequencies below approximately 500Hz, their phase response changes rapidly as a function of frequency and it cannot be strictly said that they are "inverting" or "non-inverting".)

Ordinarily, the accurate phase-matching between the two filters causes separation to be maintained comfortably in excess of 25dB above 200Hz with a very abrupt decrease in separation below that frequency. If separation decreases gradually, it implies that the phase-matching between the two filters is not to specification. (It can also indicate that one filter has not been connected into the signal path by appropriate positioning of jumper "A" or jumper "B".)

Fig. B-1 shows the nominal separation; Fig. B-2 shows the nominal frequency response of the highpass filter.

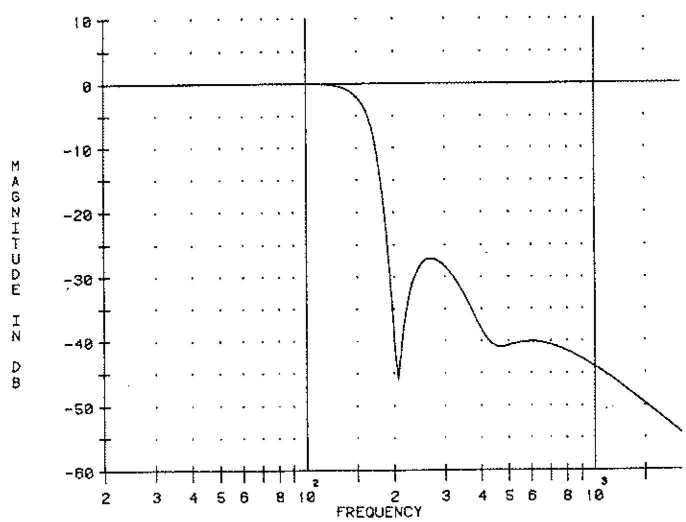

Fig. B-1: Nominal Separation

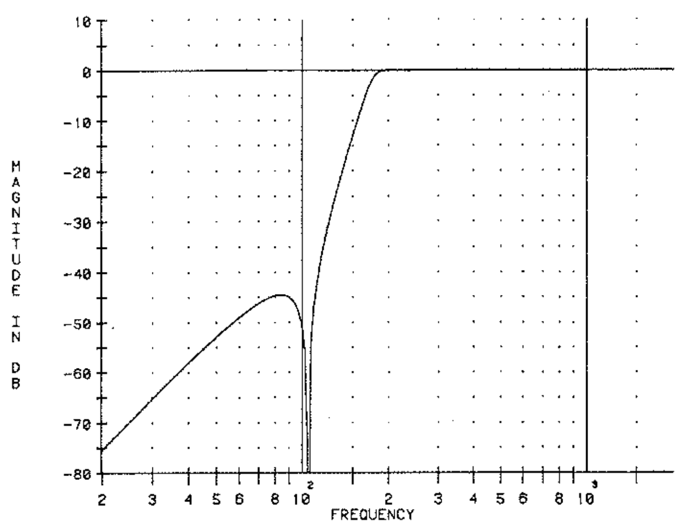

Fig. B-2: Highpass Filter Frequency Response

6.b) 5kHz Lowpass Filter: [on Card #1-S]

There are two matched unity-gain phase-corrected 5th-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. (We will discuss only the L+R channel; 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 5th-order filter's frequency response shaping is completed by IC11b and associated components, which form a 2nd-order inverting filter which can be switched from FLAT response (Q2-ON; Q1-OFF) to a peaked lowpass response (Q1-ON; Q2-OFF). The latter completes the 5th-order frequency response. IC13b and associated components form a phase corrector which is an allpass filter with flat magnitude response but with frequency-dependent phase response. This filter adds delay as necessary to make the delay of the entire filter approximately constant with frequency, minimizing overshoot.

IC12 is a quad CMOS NAND gate. When output 1 (pin 12) is HIGH (at ground), then output 2 (pin 11) is LOW (at -15VDC), and Q2 is turned ON while Q1 is turned OFF. This bypasses the lowpass filter. When the converse occurs, the filter is activated.

Both L+R and L-R filters are followed by clippers IC11a and IC3a which duplicate the function of the existing safety clippers on Cards #7 and #10. This duplication is necessary because the subsequent Single-Channel Limiter must see properly-controlled L+R and L-R peak levels to perform correctly.

6.c) Single-Channel Limiter/Stereo Enhancer: [on Card #1-S]

The L-R signal is applied to a voltage-controlled amplifier using a junction FET Q5 as the gain-control element. To prevent distortion, the L-R signal is attenuated by voltage divider R53, R54, R56, R85, R86 before being applied to the FET. R54 (SEPARATION TRIM) permits precise adjustment of the nominal loss in this attenuator. R85 (STEREO ENHANCE) 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 R48 (FET BIAS) through R49 and R50. Control circuitry consisting of comparators IC6 and IC9 and associated integration circuitry CR3, CR4, CR5, CR8, CR9, C23, C24, R50 produce 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 are a servo integrator to eliminate 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 level of the -L and -R (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. Gains are chosen such that the overall input/output gain of the Single-Channel Limiter Subsystem is unity when no G/R is occurring.

The reference voltage for comparators IC6 and IC9 is ordinarily -5.73VDC as determined by R67 and R68. Under normal OPERATE conditions CR10 is reverse-biased. However, when the mainframe is put into PROOF mode, the ±4.1V clipping reference voltages increase to approximately ±14VDC. This turns CR10 ON, pulling the threshold of the comparators up approximately 7dB and assuring that no G/R will occur in PROOF mode for any reasonable signal level.

Under normal OPERATE conditions, the outputs of Card #1-S are applied to the existing clippers on Cards #7 and #10. The thresholds of these clippers are matched within a few percent to the thresholds of CR1/CR2 and CR12/CR13 within Card #1-S. The action of CR7 and CR11 can only reduce peak levels further. Thus no significant clipping occurs in the clippers on Cards #7 and #10 when Card #1-S is installed.

7.a) Safety Clipper: [on Cards #7 and #10 (stereo only)]

Clipping is achieved with shunt clippers CR11, CR12 as buffered by IC5A. CR11, CR12 are biased by ±4.1 volt sources, realized by IC7 and associated circuitry. R75, R76 serve as a reference voltage divider from the +15V power supply. The voltage at the junction of R75 and R76 is equal to the clipping threshold -- 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.

-4.1V is created by "amplifying" the +4.1V supply in a unity-gain inverter IC7B, R78, R79. An additional current can be summed into IC7B from the POS PEAK THRESH control, R80, through R81 to vary the -4.1V supply from -4.1V to -6.4V, varying asymmetry as desired. (Negative-going signals at this point in the circuit correspond to positive peaks).

The multiband clippers are biased by means of IC8, whose circuitry is topologically identical to the ±4.1 supply discussed immediately above.

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

7.b) Supersonic Lowpass Filter: [on Cards #7 and #10 (stereo only)]

This filter requires no discussion beyond that provided in **Appendix A.** Wong and Ott (mentioned earlier) should be consulted if a further discussion of the filter topology is desired.

7.c) Transmitter Equalizer And Logic: [on Cards #8 and #9 (stereo only)]

The HF DELAY EQ is a first-order allpass network consisting of IC2A and associated components. HF DELAY EQ is created by subtracting the output of a highpass filter (formed by C1 and its load resistors R1, R2, R3, R4) from the main signal in IC2A. The time constant (and thus the frequency at which the phase shift is 90 degrees) is determined by the RC product of C1 and its loading resistors. Four different time constants for DAY/TX1, DAY/TX2, NIGHT/TX1, and NIGHT/TX2 operation may be selected by turning switching FET's Q1, Q2, Q3, Q4 ON by applying 0 volts to their gates. They are OFF when -15 volts is applied.

The HF SHELF EQ is created by means of a similar subtraction. However, only a fraction of the output of the highpass filter is subtracted from its input.

LF TILT EQ is created by circuitry inside the module. Again, four groups of controls (LF BREAKPOINT and LF EQ) are available, switched by FET's on the auxiliary tilt EQ circuit board.

The DAY/NIGHT and TX1/TX2 modes are selected by means of two identical logic circuits. The outputs of the two logic circuits form a 2-bit binary word which is decoded in binary decoder IC5A such that only one of its four output lines is at 0V (ON) at any one time, activating one of four sets of TX EQ setup controls.

We will discuss the logic associated with the DAY/NIGHT switching with the understanding that this discussion applies identically to the TX1/TX2 switching.

DAY or NIGHT modes may be selected by pulsing current through opto-isolators IC6 and IC7 respectively. Current limiting and RF suppression are provided by resistors and feedthrough capacitors within the filter box; rectification for AC control signals is provided by CR1.

IC4A and IC4B are cross-coupled as a bistable multivibrator (flip-flop). This bistable changes state whenever the transistor in one of the optoisolators turns ON and pulls its collector down to -15 volts. Local switching by means of the momentary DAY/NIGHT switch on the front panel also changes the state of the flip-flop.

Initialization circuit CR2, C11, R37 assures that the system always comes up in the "Day" mode on powerup. Upon powerup, the transition of the negative power supply from 0 to -15 volts is coupled through C11 and CR2 to IC4B. Under steady state conditions R37 pulls the anode of CR2 up to 0 volts. CR2 then effectively disconnects the powerup circuitry.

The main ("Day") output of the bistable is the output of IC4B. IC1A is an inverting buffer, and buffers the DAY/NIGHT indicator LED drive circuit.

7.d) Dematrix: [on Card #9 (stereo only)]

The dematrix circuit is electrically identical to the previous matrix circuit. The reader is referred to **7.d** of **Appendix A,** and to **4** of this **Appendix.**

7.e) Output Line Amplifier: [on Cards #8 and #9 (stereo only)]

There are two balanced line amplifiers in the mono version (9100A/1) and four such amplifiers in the stereo version (9100A/2). 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. These amplifiers together provide a +26dBm balanced output capability. This is reduced to +20dBm by the following output pad and RF filter. Both amplifiers are opamps with high output current capacity, capable of driving 600 ohm loads without further buffering.

Each amplifier is driven by its own 18-turn OUTPUT ATTEN control. AC coupling to eliminate accumulated offsets is provided by 47uF capacitors C3, C4. These capacitors 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 means of LC RFI filters which are effective at both AM and FM frequencies. These filters have been designed so that, when properly loaded, no ringing and/or overshoot will occur.

8.a) Unregulated Power Supply: [on chassis outside RF-tight enclosure]

The unregulated power supply is wholly conventional. It consists of a dual-primary transformer T101, two full-wave rectifiers CR101, CR102 and CR103, CR104, and two energy storage capacitors C101, C102.

T101's primary may be connected for 115 volt operation by paralleling its two primaries, or for 230 volt operation by connecting its two primaries in series by means of a switch. RF filtering is provided on the AC line by means of FL101. In addition, VHF and UHF RF is filtered from the unregulated DC supply lines as they enter the main chassis by means of C103, C104, C105, C106, C107, L101, L102.

The RF suppression scheme divides the chassis into three major sections. 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 RF-free. (The RF filter box, on the rear panel, interfaces the audio input and output lines with the outside world. It contains the input pads. Its connections to the main RF-tight compartment are all RF-filtered.)

8.b) +15 Volt Regulator: [on Card #PS -- rear chassis apron]

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

The 723C contains a reference voltage source, an opamp (externally compensated by means of C109 to prevent oscillation), and a current limiting transistor. The reference voltage (nominally +7.15 volts) is developed at pin 6. C108 filters high frequency noise from the reference voltage. The reference voltage is directly connected to the non-inverting input of the internal opamp, pin 5. Voltage divider R105, R106, R107 develops a precise fraction of the output voltage of the regulator at the wiper of R106. R106 adjusts this fraction. The wiper of R106 is connected to the inverting input of IC101's internal opamp. Negative feedback thus forces the voltage at the wiper of R106 to be equal to the reference voltage. Thus 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 3/4 amp, said voltage drop is sufficient to turn on the current-limit transistor inside IC101, whose base-emitter junction is connected to pins 2 and 3 of IC101. The current-limit transistor 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-blo fuse F102.

In the event that 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. However, before VR101 is damaged, this current will blow F102, thus disconnecting the circuitry from the unregulated supply. VR101's clamping action will also prevent the negative tracking supply from going any higher than -16.5 volts. If the regulator is operating properly, the current limiting circuitry will prevent F102 from blowing even if the regulator output is short-circuited.

E

Under certain unusual circumstances, the regulator may lose control of its output voltage, yet the current limiting circuit may still work. If this occurs, F102 will not blow, and VR101 will overheat and burn out. Fortunately, its failure mode is a short-circuit. It will therefore still protect the OPTIMOD-AM circuitry even in this exceptional circumstance.

8.c) -15 Volt Regulator: [on Card #PS -- on rear chassis apron]

The -15 volt regulator is an operational amplifier containing a discrete power-booster output stage with current limiting. It "amplifies" the output of the +15 volt regulator by -1, thus producing a -15 volt tracking supply. Shutdown of the +15 volt supply (due to current limit conditions or to a fault which blows F102) will also result in the -15 volt supply's shutting down.

The basic opamp is IC102; its input resistor R109 and feedback resistor R108 are equal-valued, resulting in a gain of -1 $\pm$2%. IC102's negative supply comes from the unregulated -22 volt supply. The common-mode range of the 301A opamp includes its positive power supply, thus permitting operation with IC102's positive supply at ground. Under 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-limit transistor. If the -15 volt supply is called upon to deliver more than 3/4 amp, 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/Q103 from burnout. Under these conditions, 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.

The rest of the circuitry is protected against a catastrophic failure of the -15 volt regulator by means of zener clamp VR102, CR106, and fuse F103. The operation of this circuit is identical to the operation of the corresponding circuit in the +15 volt regulator (see **8.b)**.

8.d) Miscellanous Voltage Supplies:

The operation of these supplies is extremely straightforward. No further explanation beyond that given in **Appendix** A is required.

This concludes **Appendix B (CIRCUIT DESCRIPTION).**

Appendix C:
User Access

The first part of this Appendix describes how to access those parts of OPTIMOD-AM ordinarily involved in setup, adjustment, or alignment.

The second part of the Appendix provides information on the disassembly techniques necessary to access the balance of the circuitry.

1: ROUTINE ACCESS

a) User Adjustments: To access the user adjustments, open the small access door using the key furnished. This will reveal all user-adjustable controls.

b) Line Fuse, Power Switch, and Line Voltage Selector: These are accessed by swinging down the entire front panel, which is hinged at the bottom. To avoid damage, this should be done only with the small access door locked. Using the 5/64" hex wrench supplied, remove the three hex-socket screws at the top of the front panel and carefully swing the panel out and down.

c) Circuit Cards: First, swing the front panel down (see **b**). You must then remove the subpanel by first loosening four DZUS fasteners by turning each one-quarter turn counterclockwise with a long 3/16" or 1/4" slotted-blade screwdriver. Taking care not to stress the flat cable beneath it, tilt the top of the subpanel outward and leftward to clear the upper chassis lip and the door support bail at the right. The PC cards may now be removed from their slots. But remember to do so with AC power OFF to avoid a latchup condition.

C

**** This procedure is directly reversible with cautions:

-- The subpanel should always be replaced to protect the cards from RFI.

-- DZUS fasteners turn only 1/4-turn. Don't force them, lest they be damaged in a way that is very time-consuming to repair.

NOTE

In the stereo OPTIMOD-AM (9100A/2), card slots #2 through #10 are filled. In the mono OPTIMOD-AM (9100A/1), slots #5, #9, and #10 are not filled. Slot #1 is reserved for the optional lowpass filter card, which may be installed in either stereo or mono units. The power supply regulator is on a small card mounted on the inside of the rear panel behind the card sockets.

2: SERVICE ACCESS

General Cautions: These apply to all the procedures described below.

-- For best RFI protection, replace <u>all</u> screws and tighten normally to achieve firm contact.

-- If screws are lost, replace them with screws of the same length, since longer screws may cause mechanical interference or internal short circuits.

-- Most screws used in OPTIMOD-AM are binding head to achieve secure fastening without lockwashers. If a pan head screw is substituted, use an internal star lockwasher to retain this security.

-- Plating on all screws is Cadmium type II. Almost any other plating is acceptable unless corrosive atmosphere is present.

a) Cover Removal: Removing the top or bottom covers is tedious because thirty screws must be removed. (The large number of screws is necessary to achieve an RF-tight seal.) Luckily, most service access can be achieved without removing either cover! Specific instructions for doing this are found further below.

If you wish to remove either cover, simply remove all thirty screws.

**** This procedure is directly reversible with cautions:

-- When replacing a cover, align it as closely as possible with the corresponding holes, and start all screws. After all screws have been started, tighten all screws to normal tightness, "inland" screws first.

b) Access To Area Behind Rear Panel: If the covers are still in place, they needn't be removed.

Remove eight screws holding the top cover to the flange of the rear panel. Remove the corresponding eight screws from the bottom cover. The rear panel will remain solidly in place.

Set the chassis, bottom cover down, on a pad on a table. Allow 6" (15cm) between the rear panel of the chassis and the table edge. Unplug the power cord.

Now remove three groups of three screws which are circled in black on the rear panel.

VERY carefully and slowly, pull the rear panel about 3/4" (2cm) toward you, and tilt the top edge down until the rear panel is horizontal and resting on the table.

CAUTION

Watch for snags in the internal wiring, and for any stress on the ceramic feedthrough capacitors on the divider wall or RF filter box. These capacitors are very fragile and difficult to replace.

**** This procedure is directly reversible with cautions:

-- When positioning the rear panel over the corresponding holes, make sure that no wires are pinched under the flanges. Start, but do not tighten all nine screws. Observe the areas where the flanges on the rear panel meet the flanges on the side panels. Adjust the rear panel so that the flanges line up in order to provide a flat mounting surface for the cover when tightened.

c) Access To RF Filter Card: First open the rear panel (procedure **b** above).

Remove the four screws which fasten the lid of the RF filter box to the box and carefully remove the lid from the box.

This will reveal the internal circuit card, which is attached to the rear panel by four #4-40 screws and by the tails of the barrier strips which are soldered to the card. Removing this card for component replacement requires unsoldering all of the tails of the barrier strip from the circuit card, as well as removing the four screws holding the filter box. This is tedious. Instead, we suggest clipping out the defective component from the topside of the card and installing its replacement by tack-soldering to the old leads. If done carefully, this procedure can be adequately reliable as long as the chassis is not subject to severe vibration.

**** This procedure is directly reversible with cautions:

-- If components have been replaced, make sure that reassembly will not result in crushing of the component against the lid.

d) Access To Unregulated Power Supply Chamber: If the covers are not already removed, remove the five cover screws which attach the top cover to the flange of the left side panel. Remove the corresponding five screws from the bottom cover.

Open the front panel. (See **1.b** above.)

Remove the shoulder screw that attaches the door-support bail to the left chassis wall. Note that there is a nylon washer between the bail and chassis wall which prevents scraping.

Turn the chassis so that the left wall is facing you. Remove the left rack flange by removing the six unrecessed screws.

Remove the three screws that attach the rear panel to the main (steel) side panel.

Remove the remaining six screws and gently lift off the side panel by pulling outward.

**** This procedure is directly reversible with cautions:

-- Position the steel side panel and start, but do not tighten, all nine screws. Observe the areas where the flanges meet the rear panel and internal bulkhead, and align the flanges so that the covers will seat on a flat mounting surface.

e) Removal Of Card #PS (The DC Regulator Card) From Rear Panel And Power Transistor Replacement: Because the removal procedure is complex, this card was designed to permit many servicing operations to be performed without removing the card from the chassis.

IC's are conventionally socketed. Many unsocketed components can be replaced from the topside by tack-soldering the new component to the lead stubs of the old clipped-out component.

CAUTION

The rear panel serves as a heat dissipator for the power transistors. Proper contact is necessary to insure sufficient transistor cooling. Please follow instructions carefully.

If the card must be removed, do it as follows:

Remove the four press-fit plastic plugs on the power transistor covers with needle-nose pliers. This will reveal the transistor mounting screws. Remove the four screws holding the power transistors.

VERY carefully and slowly pull each transistor from its socket. If, as you do this, the silicone rubber insulator tends to stick to the panel, release it from the panel such that it sticks to the bottom of the transistor instead. After you remove each transistor, press its insulator back in close contact with it pending reinstallation.

NOTE

> These insulators form themselves to the bottom surface of each transistor. Since they take a "set", they should not be interchanged or reversed. If you have to replace a power transistor, you may re-use the insulator if it is in good condition. With care, it will re-form itself as necessary. Otherwise, use a conventional mica insulator and white silicone heat-conducting compound.

Open the rear panel (procedure **b**). With the transistors removed, it is possible to release the circuit card from its plastic post mounts by squeezing the tangs in each of the four corners to permit pulling the card off the posts.

**** This procedure is directly reversible with cautions:

-- See the discussion above regarding heat-conduction insulators

-- The power transistor sockets must be correctly aligned with the rear-panel holes to prevent short circuits.

-- The screws mounting the transistors should be tightened evenly. For best thermal contact, tighten each screw a small amount, alternating between screws. Tighten securely, but not enough to damage the threads in the sockets.

-- Note that there must be a split lockwasher under each screwhead to accomodate thermal cycling.

-- The Thermalloy (TM) plastic cover does not attach in a conventional or readily obvious way. It rides on the circumference of the special split lockwasher and does not (and should not) become captured under the head of the screw. Consequently, the cover may be slightly loose even after screws are tightened securely. This is normal, and should not (and cannot) be corrected.

-- Be sure to reinstall the press-fit plugs that cover the screwheads.

Appendix D:
Field Audit-Of-Performance

GENERAL

This Appendix provides instructions enabling OPTIMOD-AM users to check the performance of their units using test equipment likely to be found in a well-equipped AM station. This procedure is a starting point for detecting and diagnosing a problem that you believe is caused by OPTIMOD-AM. It is also useful in routine maintenance, and can be used at Proof time to check routine equipment performance, providing more data than the Proof alone provides. By its nature, it is limited in scope to discovering static problems. A dynamic problem in the AGC circuitry (caused by the failure of a timing module on Card #6, for example) would not tend to be discovered by performing these tests.

For this reason, measurements must always be complemented by listening. If you are well-acquainted with the "sound" of OPTIMOD-AM as adjusted to your tastes, then faults that develop will ordinarily be readily detectable by ear.

If audio problems develop, many engineers immediately blame their processing. However, as is the case with any processing, faults in the audio equipment preceding OPTIMOD-AM will be magnified by the action of the processing. Program material that is marginally distorted at the OPTIMOD-AM input, for example, is likely to be unlistenable by the time it emerges from the output when aggressive processing is used. In addition, be sensitive to possible defects in the monitoring equipment; verify that a problem can be observed on at least two receivers before assuming that the problem is with your OPTIMOD-AM.

REQUIRED EQUIPMENT

a) Audio Oscillator. An ultra-low-distortion type like the Sound Technology 1710B is preferred. However, a Heathkit or Eico-type oscillator (such as Heath IG-72) can be used to obtain approximate results, provided that residual distortion has been verified to be below 0.1%.

b) Noise and Distortion (N&D) Test Set. Once again, a high-performance type like the Sound Technology is preferred, but not required.

c) General-Purpose Oscilloscope. DC-coupled, dual-trace, with at least 5mHz vertical bandwidth. This is used to monitor the output of the N&D Test Set.

d) Pink Noise Generator. A suitable circuit is shown in Fig. D-1.

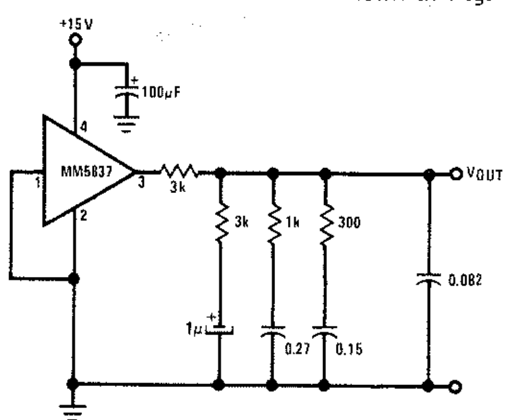

Fig. D-1: Pink Noise Generator
(From National Semiconductor Audio/Radio Handbook)

AUDIO PROCESSING

It is often more convenient to make measurements on the bench away from high RF fields which could affect results. For example, in a high RF field it is very difficult to accurately measure the very low THD produced by a properly-operating OPTIMOD-AM at most frequencies. However, in an emergency situation (is there any other kind?!), it is usually possible to do measurements under high-RF conditions which will reveal many of the grosser faults which could develop in the OPTIMOD-AM circuitry.

The input of most test equipment is unbalanced. Measurements should therefore be made between circuit ground (available on the rear-panel barrier strip) and the (+) terminal of the OPTIMOD-AM being used. To assure correct response from the output RFI suppression network, load the main output with a 300 ohm ±5% resistor between the (+) input and circuit ground.

a) **Standard Control Setup:** Record the normal settings of the controls so that they can be restored after the measurements have been completed. Then set the controls as follows:

INPUT ATTEN	7
EQ CONTROLS	don't care
EQ IN/OUT	OUT
CLIPPING	-4
GATE THRESH	HI
POS PEAK THRESH	100%
AUX INPUT ATTEN	don't care
TIME CONSTANT	don't care
TX EQ IN/OUT	OUT
OUTPUT ATTEN	retain normal settings

Other controls will be adjusted as necessary in the course of the Procedure.

b) **Skeleton Proof:** If you have a stereo unit (9100A/2), restrap Cards #8 and #9 to produce L/R output if they are currently in L+R/L-R mode. [**Option 2** of **Initialization Options** in **Installation (Part 3)** provides instructions for restrapping.]

The following instructions apply to mono units and to the Left channel of stereo units. In the case of stereo units, the Skeleton Proof should be repeated for the Right channel.

1) Place the MODE switch in PROOF.

2) Connect a low-distortion sinewave oscillator to the OPTIMOD-AM Left input. Set its frequency to 1kHz. Switch the METER FUNCTION switch to L AGC, and adjust the oscillator output level to produce a reading of -6VU.

3) Switch the METER FUNCTION switch to L 12KHZ FILTER. Adjust the L DENSITY control to produce a reading of -6VU.

4) **Frequency Response:** Connect the N&D set between OPTIMOD-AM's L TX1 (+) output and circuit ground. Use the 1kHz output as a "0dB" reference level. Measure the frequency response between 50 and 10,000Hz. It should be within ±1dB of the 1kHz response just observed. (A sweep generator and scope or a test set like the Tektronix 5L4N Spectrum Analyzer/Tracking Generator can be used to sweep the system, displaying more complete frequency response information than that obtained by spot frequency checks using a conventional oscillator.)

The frequency response measuring procedure described herein measures the total response, including the 12kHz input and output lowpass filters, the 50Hz highpass filter, the supersonic lowpass filter, and the Six-Band limiter, including all pre- and post- limiter crossover filters.

[Note: If the optional Stereo Enhancement Card (Card #1-S) is installed, it is recommended that frequency response measurements be made with this card out of the circuit. To do this, temporarily remove Card #1-S from its slot and temporarily restrap Jumper "A" on Card #7 (and Card #10 -- stereo only) to the OUT position. (See **Option 4** in **Part 3** of this manual.) A full alignment and performance evaluation procedure for Card #1-S is found in Instructions for doing this are provided in **Appendix H: Installation Of The Optional Lowpass Filter Card.]**

If the response is outside specification, use signal-tracing techniques to determine the point in the circuitry at which the frequency response error occurs. Signal-tracing techniques are described in **Trouble Diagnosis and Correction (Appendix F).** Before checking the filters, make sure that the quiescent gain of all VCA's in the Six-Band Limiter are correct, producing maximally-flat response through the Six-Band section.

5) **Program Equalizer Response:** If you wish to evaluate the performance of the Program Equalizer, this should be done at this stage in the procedure.

Turn the BASS EQ control to "0" and the HF EQ control to "22". If a module other than the GREEN module is installed in the socket on Card #4 (and #5 -- stereo only), replace it temporarily with the GREEN module. Reduce the output level of the oscillator by 20dB, and switch the EQ IN/OUT switch IN. Measure the frequency response of the system, and compare it with the ideal response of the HF equalizer shown in Fig. D-2 below. Sweeping the system as described above will provide the most information. (Note that the response at 6kHz and above will vary slightly from unit to unit, and you may have to slightly adjust the HF EQ control to duplicate our graph. After this adjustment has been made, you should be able to duplicate the ideal response ±2dB.)

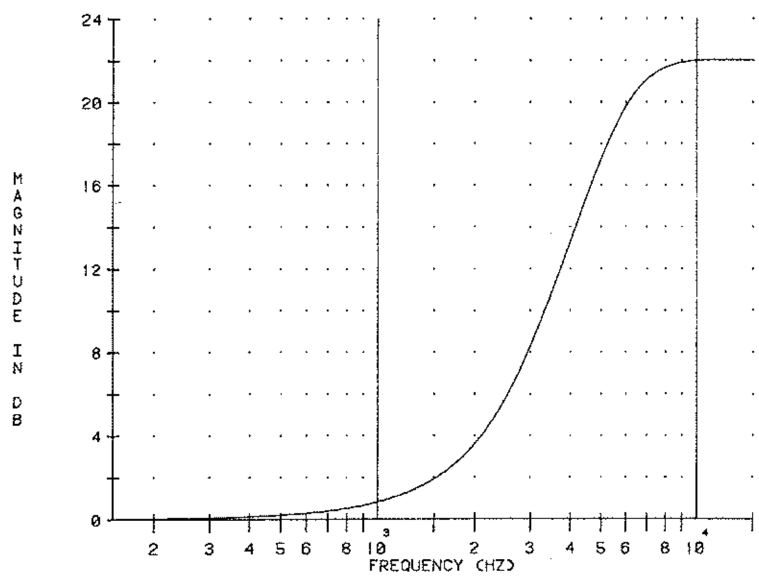

Fig. D-2: HF Equalizer Response At Maximum EQ

To check the bass equalizer, first defeat the HF equalizer by turning the HF EQ control to "0". Then center the BASS TUN and BASS BW controls, and set the BASS EQ control at "6". Verify that 6dB of bass boost is produced, ±1dB, centered at approximately 87Hz, ±10%.

When you are finished with the equalizer response checks, switch the EQ IN/OUT switch OUT. If you temporarily installed the GREEN module for these tests, reinstall the original module.

6) **Distortion:** Using the same levels and setup as in (4) above, measure the THD at the OPTIMOD-AM output. It will ordinarily be under 0.1%, 50-10,000Hz, although this performance is not guaranteed. Guaranteed specifications are provided in **Appendix L.**

   If an SMPTE IM analyzer is available, the IMD may also be measured. It will ordinarily be approximately 0.2%.

7) **Noise:** Apply 1kHz to the OPTIMOD-AM input, and verify that both the L AGC and L 12KHZ FILTER positions on the VU meter read "-6".

   The peak level produced by this setup is 11dB below 100% modulation as measured at the OPTIMOD-AM output. Set the N&D meter "0dB" reference 11dB higher than the level measured. Then remove the 1kHz from the OPTIMOD-AM input and measure the noise at the OPTIMOD-AM output. It should be approximately -80dB below the "0dB" reference, and should in no case exceed -75dB. [If substantial hum is observed in the output, disconnect any leads from the OPTIMOD-AM input and short the (+) and (-) terminals together. If hum is still observed, carefully check the grounding scheme of the instruments, making sure that no ground loops have been introduced through the AC power line. Ground loops can be caused by grounding-type AC plugs.]

8) **Static Separation** (9100A/2 only): Apply the sinewave oscillator to the OPTIMOD-AM L input. Adjust its level as before to produce a reading of -6VU on the VU meter in L AGC mode.

   Connect the N&D meter to the OPTIMOD-AM L output and read the level. Calibrate the N&D meter so that this level corresponds to "0dB".

   Now connect the N&D meter to the OPTIMOD-AM R output, and measure the output level at 50, 100, 400, 1000, 2500, 5000, 7500, and 10000 Hz. In a properly operating OPTIMOD-AM, none of these readings should exceed -30dB, although the guaranteed specification is looser. (If the unit was correctly set up before being removed from service, the balance of the L and R OUTPUT ATTEN controls will be sufficiently accurate to avoid compromising the validity of the readings. If OPTIMOD-AM was not set up before being removed from service, balance the L and R OUTPUT ATTEN controls before making this separation measurement.)

   (Note: If the optional 5kHz L-R filter is in the circuit, measure separation only to 5kHz. Separation should still exceed -30dB at all frequencies except 5kHz. At 5kHz, separation may be as low as -25dB. Essentially no separation exists at 7500 and 10000Hz.)

   Repeat the procedure symmetrically, driving the OPTIMOD-AM R input and observing the L output to check R into L separation.

c) **Operate-Mode Measurements**

These measurements evaluate certain static and quasi-static characteristics of OPTIMOD-AM in its normal OPERATE mode. Normal measurements given herein are provided for service guidance only and are not guaranteed. As in the PROOF mode measurements above, these measurements should be repeated for both the left and right channels. Standard control settings should be as in (a) above.

Because the bass rolloff in the control loop of the Broadband AGC can cause certain stages to be overdriven when making sinewave measurements at low frequencies, it is necessary that the Broadband AGC be defeated to make the following measurements. This is achieved by moving a jumper on Card #6 according to instructions provided in **Option 6** of **Initialization Options** in **Installation, Part 3.** Access to Card #6 is obtained by following the instructions provided in **User Access (Appendix C).**

1) **Sinewave THD Measurements:** Set the MODE switch to OPERATE. Reconnect the sinewave oscillator to the OPTIMOD-AM input. Adjust its frequency to 1.6kHz, and its output until the L AGC position of the OPTIMOD-AM VU meter reads -6VU. Verify that the Broadband AGC meter reads "0", and that the GATED lamp is ON, assuring that the Broadband AGC has been successfully defeated and is operating with normal gain.

   Advance the DENSITY control until the 1.6K Band Limiter G/R meter reads 10dB G/R. Then measure the THD at the OPTIMOD-AM output at 50, 100, 400, 1K, 2.5K, 5K, 7.5K, and 10K Hz. Except at 50Hz, THD should be approximately 0.1% or less. At 50Hz, it should be approximately 0.2%. Note that these distortion readings may vary quite widely, although they should not exceed 0.25%.

   Set the oscillator frequency to 1kHz, and advance the CLIPPING control until the THD begins to increase suddenly, indicating that the multiband clipper has started to clip. This should occur at approximately "0dB" on the CLIPPING control.

   Advance the CLIPPING control to "+2dB", and measure the THD. It should be approximately 4%, and should consist almost entirely of odd harmonics -- mainly third-order.

   Now temporarily adjust the POS PEAK THRESH control toward "150%" and note that the distortion residual as observed at the output of the distortion analyzer changes shape, and that a second-harmonic component is added.

   Return the POS PEAK THRESH control to 100%.

2) **Pink Noise Tests:** Restore the Broadband Compressor to operation by replacing the Card #6 jumper moved in step (1) above.

   Connect a pink noise generator to the OPTIMOD-AM L input. Advance its output level until the OPTIMOD-AM Broadband G/R meter reads "0".

   Advance the DENSITY control until the 700Hz Band G/R meter reads "10dB". Observe the readings of the other band G/R meters and see if they match the expected readings in Table D-1.

Table D-1
Band Limiter G/R Meter Readings
With Pink Noise Excitation
(Tolerance=±3dB)

Band	dB G/R
150Hz	10
420Hz	13
700Hz	10
1.6kHz	12
3.7kHz	8
6.2kHz	9

A reading outside of tolerance can indicate a problem with the control circuitry of a given band-limiter. Because of the non-periodic nature of pink noise, certain failures in the control circuitry dynamic response may also be indicated in these tests. Such failures ordinarily require return of Card #6 to the factory for diagnosis and repair.

3) **Dynamic Separation** (9100A/2 only): Excite the OPTIMOD-AM L input with pink noise, and adjust the controls for the same response as in (2) immediately above.

Making sure that the POS PEAK THRESH control is set at "100%", and the TX EQ is OUT, compare the levels at the R and L OPTIMOD-AM outputs to determine dynamic separation. This will typically be approximately 30dB. If separation is notably poorer than this, it implies that mistracking is occurring between circuit elements in the sum and difference channels. A useful troubleshooting technique is to employ a voltmeter or N&D set with a true differential input. Assuming left-only excitation, if the two sides of the differential input are connected to corresponding points in the sum and difference channels, complete cancellation will ideally occur. The amount of residual signal measured differentially thus gives some measure of the separation at a given point in the circuit.

By tracing the sum-and-difference path from its input (the matrix) to its output (the dematrix), it should be clear where separation becomes poor, and therefore, which circuit element pair in the sum and difference channels is failing to track dynamically.

(Note that a common-mode signal due to gain imbalance may exist between the sum and difference channels. This imbalance is later cancelled by means of the SEPARATION TRIM control on card #10. The differential voltmeter cannot null this imbalance, and it may therefore indicate poorer separation than that actually being produced by the system.)

The separation test should be repeated symmetrically, using R excitation and checking R into L separation at the OPTIMOD-AM output. Note that asymmetrical dynamic separation can be caused by operation of the POSITIVE PEAK THRESH control beyond "100%".

For a comprehensive discussion of **Trouble Diagnosis and Correction,** refer to **Appendix F.**

This concludes the **Field Audit Of Performance.** Be sure to restore all OPTIMOD-AM control settings before reinstalling the unit.

Appendix E:
Field Alignment Procedure

1: GENERAL

The following section describes how to align and calibrate OPTIMOD-AM in the field. It is included primarily for purposes of reference as routine alignment is neither necessary nor desireable due to the high stability of the circuitry.

WARNING!

IF CALIBRATION IS NECESSARY, WE STRONGLY RECOMMEND THAT THE CARD IN QUESTION BE RETURNED TO THE FACTORY FOR CALIBRATION BY OUR EXPERIENCED TECHNICIANS, WHO HAVE ACCESS TO SPECIAL TEST FIXTURES AND TO A SUPPLY OF EXACT-REPLACEMENT SPARE PARTS. ONLY IN AN UNUSUAL SITUATION SHOULD AN ATTEMPT BE MADE TO ALIGN AND CALIBRATE OPTIMOD-AM IN THE FIELD.

The factory aligns each card independently to a standard so that all cards made will be interchangeable. The user does not have access to the special test fixtures necessary to complete independent alignment of the cards. The user thus must use his own OPTIMOD-AM chassis as a test fixture and align the entire unit as a system. Universal card interchangeability may then not be optimum. Even so, the unit can meet all specifications and perform properly.

This section is organized on a card-by-card basis. Cards should be calibrated in the same order as their order in the signal path, from input to output. This will occur naturally if the instructions in this section are followed in order from beginning to end. If a card later in the signal path is aligned while an earlier card is misaligned, the later card may not be correctly aligned even if the instructions for that card are followed conscientiously.

OPTIMOD-AM was conservatively designed with high-precision parts to minimize the number of alignment controls necessary to achieve accurate performance. Cards 4, 6, and 8 in mono 9100A/1 units, and Cards 4, 5, 6, 8, and 9 in stereo 9100A/2 units require no alignment. However, highest performance is assured by compensating for tolerance build-up in the non-alignable cards by adjustment of alignment controls on other cards. In particular, the quiescent gains of the band VCA's on Cards #2 and #3 are aligned to compensate for cumulative tolerances in the filters and crossovers throughout the rest of the system.

While specifications will usually be met after a faulty card is replaced with a factory-aligned card, best results are obtained by a touch-up alignment after such replacement. This is particularly true if Cards #2 or #3 are replaced, in which case it is advisable to perform parts **(d)** and **(e)** (stereo only) of the Card #2 and #3 alignment procedure.

Before commencing alignment, remove OPTIMOD-AM from its normal rack mounting location and place it on the test bench away from RF fields. Jumper the chassis and circuit grounds together on the rear-panel barrier strip. Note the normal positions of the setup controls and of the jumpers on the cards to aid reinstallation.

E

2: REQUIRED TEST EQUIPMENT

The following test equipment (or close equivalents) is required. It is assumed that the technician is thoroughly familiar with the operation of this equipment.

a) Digital Voltmeter, accurate to $\pm 0.1\%$
b) Oscilloscope, DC-coupled, dual-trace, triggered-sweep, with 5MHz or better vertical bandwidth
c) Ultra-Low Distortion Sinewave Oscillator/THD Test Set/AC VTVM (Sound Technology 1700B or 1710B)
d) Low Frequency Spectrum Analyzer with Tracking Generator (Tektronix 5L4N plug-in with 5111 Bistable Storage Mainframe)
[Note: A sweep generator with logarithmic sweep capabilities can be substituted for the 5L4N. It is used with the oscilloscope (in X/Y mode) in a manner described in the manufacturer's instructions for the Sweep Generator.]
e) 1 ea. 10.0K 1% 1/8w metalfilm resistor (actual wattage not critical)
f) 1 ea. short test lead with miniature alligator clips or "E-Z-Hooks" on both ends.

REFER TO THE FOLD-OUT SCHEMATICS AND PARTS LOCATOR IN **APPENDIX J.**

3) **Card #PS (Power Supply Regulator)**

3: POWER SUPPLY CARD

a) Measure the voltage across C111 (or other convenient point on the +15 volt bus) with the DVM. Adjust R106 until the DVM reads +15.00 volts.

b) Measure the voltage across C112 (or other convenient point on the -15 volt bus). Make sure that the voltage is between -14.85 and -15.15 volts. If it is not, refer to **Appendix B (CIRCUIT DESCRIPTION),** paragraph **8.c** for troubleshooting hints.

BEFORE ALIGNING EACH CARD AS DESCRIBED IN THE INSTRUCTIONS BELOW, REMOVE THE CARD OF INTEREST FROM ITS SLOT AND PLUG THE EXTENDER INTO THE EMPTY CARD SLOT. PLUG THE CARD INTO THE CARD EXTENDER. THIS WILL ALLOW ACCESS TO THE ALIGNMENT TRIMMERS AND TEST POINTS.

4: CARDS #2 AND #3

Concept: All OPTIMOD-AM's (including the mono 9100A/1) are fully equipped with stereo VCA's. This was done to facilitate stereo conversion in the field, as the VCA's can be fully factory aligned and calibrated.

First, the second-harmonic distortion and control-voltage feedthrough of each VCA is nulled. Then VCA gains are set.

All twelve VCA's employed in the stereo six-band limiter are designed to have the same nominal gain (41.4dB) when measured from their Card #2 or #3 input to their output. (An exception is the L+R and L-R Band-6 VCA's on Card #3, which have 46.4dB nominal gain, permitting them to take up to 30dB gain reduction.) Further loss is incorporated in certain VCA's by placing additional resistors in series with the VCA inputs. These additional resistors are located on the crossover cards (#4 and #5).

For purposes of field alignment, the gain of the Broadband VCA's are first standardized. Then the entire OPTIMOD-AM system is swept, and the gains of the band-VCA's are adjusted to achieve flattest frequency response (and, in stereo units only, best separation).

The following instructions refer to reference designators on Card #2. When referring to a band-VCA, we will use the reference designators for left-channel band #1 (150Hz) for convenience, with the understanding that the instructions can be extended to all other band-VCA's by exact analogy.

Cards #2 and #3 are identical, except that Card #3 does not contain Broadband VCA's. The VCA's for bands 1, 3, and 5 are located on Card #2; the VCA's for bands 2, 4, and 6 are on Card #3.

4.a) Distortion Null (all VCA's): Set the MODE switch (on Card #6) to PROOF. Connect the output of the oscillator in series with a 10.0K ±1% resistor (wattage not critical), and connect the resistor to a short jumper lead with a miniature alligator clip or "E-Z-Hook" test lead at its other end. [If you cannot find a 1% resistor, use a 10K 5% 1/4 carbon film resistor. This will slightly (but not fatally) compromise the accuracy of the gain trim adjustments in **(c)** below.]

Set the oscillator output to 1kHz at -10dBm. Connect the test clip to the (-) input of the opamp associated with the VCA. Connect this clip to the "Input Resistor" on its "Input IC" side. (The "Input Resistor" and "Input IC" for each VCA are tabulated in Table E-1.) For example, in the case of the Left Broadband VCA, connect the clip to the IC17 side of R1.

Connect the N&D meter to the output of the VCA-under-test. The outputs of the VCA's are available in two places: the "Output IC" and the "Output Card Connector", as shown in Table E-1. (Use whichever you find most convenient.) You should observe a level of approximately +10dBm at the output of the VCA-under-test.

VCA IDENTIFIER	INPUT RESISTOR	INPUT IC	OUTPUT IC	OUTPUT CARD CONNECTOR
L Broadband	R1	IC17	IC16A	pin 19, card #2
R Broadband	R19	IC19	IC16B	pin W, card #2
L 150Hz	R59	IC1A	IC1B	pin F, card #2
R 150Hz	R77	IC3A	IC3B	pin H, card #2
L 400Hz	R59	IC1A	IC1B	pin F, card #3
R 400Hz	R77	IC3A	IC3B	pin H, card #3
L 700Hz	R30	IC6A	IC6B	pin J, card #2
R 700Hz	R48	IC8A	IC8B	pin K, card #2
L 1.6kHz	R30	IC6A	IC6B	pin J, card #3
R 1.6kHz	R48	IC8A	IC8B	pin K, card #3
L 3.7kHz	R87	IC12A	IC12B	pin L, card #2
R 3.7kHz	R105	IC14A	IC14B	pin M, card #2
L 6.2kHz	R87	IC12A	IC12B	pin L, card #3
R 6.2kHz	R105	IC14A	IC14B	pin M, card #3

NOTES:

1) Broadband test point is pin #2 of IC17 or IC19.
2) Six-Band test point is pin #6 of "Input IC". "Input Resistor" is connected to this point.
3) Output of L Broadband VCA is found on "Output Card Connector" and also on pin #7 of IC16. Outputs of all other VCA's are found on their "Output Card Connector"'s and also on pin #1 of their "Output IC"'s.

Table E-1
VCA Test Points

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Measure the THD produced by each of the VCA's in turn. Adjust the VCA-under-test's DISTORTION NULL control to minimize distortion.

4.b) Thump Null (all VCA's):

Note: Before thump can be nulled, distortion must be nulled using procedure **(a)** immediately above. Readjusting any DIST NULL trimmer requires the THUMP NULL trimmer for that VCA to be renulled.

The Thump Null procedure is performed first for all VCA's on Card #2, then for all VCA's on Card #3. The Card #2 procedure will be specifically described; the procedure for Card #3 is deduced by exact analogy.

Set the oscillator output level to -30dBm, and its frequency to 1kHz (where it should be already). Without disturbing the connection between the oscillator, the 10K resistor, and the test clip created in **(a)** above, disconnect the test clip from other circuitry, and connect it to the junction of R115 and CR7. This modulates the bias current to all VCA's on the card at a 1kHz rate.

Now observe the output of each VCA in turn (see Table E-1), and adjust the appropriate THUMP NULL control to minimize the level of 1kHz seen.

CAUTION!

The junction of R115 and CR7 is a sensitive circuit point. It is possible to cause IC10A and associated circuitry to enter a "latchup" mode if noise spikes or excessive levels (such as an oscillator output greater than -30dBm) are coupled to this point. Latchup is indicated by the VCAs' taking very high gain, and by the DC voltage at the output of IC10A being approximately +0.6V instead of its correct -0.6V.

To clear a latchup, turn off AC power to the chassis for several seconds and then restore it.

4.c) Broadband VCA Gain Calibrate: Check to make sure that the MODE switch is in PROOF, and that the chassis has been powered long enough for the Broadband AGC G/R meter to settle to "0" (10dB G/R).

Connect the test clip (connected to the 10.0K resistor) to the input test point of the L Broadband VCA (see Table E-1). Connect the N&D meter to the VCA output.

Set the oscillator output to exactly -10dBm as read at its output terminals. Retain the 1kHz frequency. Adjust R13 (L GAIN TRIM) to produce +1.6dBm at the VCA output.

Repeat the procedure for the R Broadband VCA, referring to Table E-1 for the appropriate test points.

4.d) L+R Six-Band Limiter VCA Gain Calibrate:

1) Connect the test clip (with 10K resistor) to the input test point of the 150Hz (Band 1) L+R VCA (see Table E-1). Set the output level of the oscillator to -10dBm and its frequency to 1Khz. (These settings should already exist.) Connect the N&D meter to the output of the VCA. Adjust R74 until +10.6dBm is observed at the VCA output.

You have now set a reference gain for Band 1. THE SETTING OF R74 MUST NOT BE CHANGED IN THE PROCEDURE BELOW!

2) Disconnect the test clip from any OPTIMOD-AM circuitry. Remove power from the OPTIMOD-AM chassis, and return all cards to their slots. Restore power, and wait for the Broadband G/R meter to settle to "0". While you are waiting, connect the sweep generator or 5L4N tracking generator to the OPTIMOD-AM L Input.

3) Make sure that both EQ IN/OUT switches and the TX EQ IN/OUT switch are OUT. Adjust the OPTIMOD-AM L INPUT ATTEN and/or the sweep generator output level to achieve a reading of approximately -6VU on the OPTIMOD-AM VU meter in L AGC mode. Adjust the L DENSITY control to achieve a reading of -6VU on the OPTIMOD-AM VU meter in L+R 12KHZ FILTER mode. (This assures that clipping will not occur in any circuitry.)

4) If you have a stereo unit, temporarily restrap Cards #8 and #9 for L+R/L-R operation. [See **Initialization Option #2** in **Installation (Part 3)** for instructions.] A mono unit should be correctly strapped already.

5) Connect the vertical input of the scope (or the input of the 5L4N) to the OPTIMOD-AM L+R output. Connect the horizontal input of the scope to the sweep ramp of the sweep generator. Operate the sweep generator from 50-12,000Hz logarithmically (or operate the 5L4N in its 20-20kHz log sweep mode at 2dB/division.)

You now should be observing the swept response of the entire OPTIMOD-AM system. Adjust the VCA GAIN controls and bands 2-5 [i.e. R74 (Card #3), R45 (Cards #2 and #3), and R102 (Cards #2 and #3)] to achieve maximally-flat response. A response better than ±1dB, 50-10,000Hz should be achievable. DO NOT ADJUST R74 ON CARD #2; IT IS THE REFERENCE GAIN AGAINST WHICH THE OTHER BANDS ARE ADJUSTED. (All of these trimmers can be adjusted from the front of the cards without extending them.)

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4.e) Separation (L-R VCA Trim: Stereo Units Only):

Temporarily restrap Card #8 and #9 for L/R operation if they are not already strapped for this mode. If Optional Stereo Enhance Card #1-S is installed, it is necessary to assure that 12kHz bandwidth is achieved. If Jumper "E" on Card #1-S is strapped in the "5kHz ALL TIMES" position, it will be necessary to temporarily restrap this jumper in the "12kHz ALL TIMES" position. If this jumper is not strapped in the "5kHz ALL TIMES" position, selecting DAY mode will guarantee 12kHz bandwidth. See **Appendix H.**

With the sweep generator still connected to the OPTIMOD-AM L Input, observe the OPTIMOD-AM R Output. This represents L-into-R crosstalk as a function of frequency.

Adjust all six VCA BALANCE controls (R86, R57, and R114 on both Card #2 and #3) to achieve the best separation from 50-10,000Hz. (While these trimmers are located some distance back on the card, they can nevertheless be adjusted from the front of the card without extending it. Use a long plastic alignment tool or non-metallic screwdriver to avoid shorts.)

The separation curve represents the amplitude and phase-matching between the L+R and L-R channels, and will ordinarily be quite ragged. Adjust the trimmers so that maximum separation is achieved throughout the frequency range. Do not permit separation to deteriorate in a small band of frequencies to achieve deeper nulls elsewhere.

Ordinarily, better than 35dB separation will be achievable throughout the band. Please note, however, that the guaranteed specification is looser.

This concludes alignment of Cards #2 and #3. These cards should already be installed in their slots.

5: CARDS #7 AND #10 (STEREO)

These cards contain the post-compressor crossovers, multiband distortion-cancelled clipper, output 12kHz lowpass filter, safety clipper, and supersonic lowpass filter. Card #7 contains only one alignment control; Card #10 contains two controls.

Alignment is quite straightforward. In addition, several optional steps are included which permit the user to verify the performance of the various non-alignable crossovers and filters within the cards. This is particularly easy to do because virtually all tests can be done "differentially": the same test signal is sent through two supposedly identical signal paths of opposite polarities. When the outputs of the two paths are added, complete cancellation of the signal should occur. If the cancellation fails, then a fault exists in either, or both, of the signal paths. Conversely, if cancellation succeeds, both signal paths must be good.

5.a) Optional Verification Of Main Signal Cancellation From Distortion-Cancel Sidechain

Extend Card #7. Connect the output of the sweep generator or 5L4N tracking generator to the OPTIMOD-AM L Input. Adjust the OPTIMOD-AM L INPUT ATTEN and/or the output level of the sweep generator to produce a reading of approximately -6VU on the OPTIMOD-AM VU meter in L AGC mode. Set the OPTIMOD-AM L DENSITY control to produce -6VU on the VU meter in L+R 12KHZ FILTER mode. Sweep logarithmically from 20-20kHz. [This equipment setup is identical to the one in parts **(d)** and **(e)** of **4** immediately above.]

Connect the vertical input of the scope or the input of the 5L4N to pin 7 of IC5 (the output of the supersonic lowpass filter). The sweep should be flat ±1dB. Use the level observed as a "0dB reference" for the next step.

Now observe pin 1 of IC6 (the distortion-cancel summing amp). Verifying that the MODE switch is on PROOF so that no clipping can occur, observe the swept response and make sure that it is at least 38dB below the level observed immediately above at pin 7 of IC5, 50-10,000Hz.

This tests the matching of the inverting and non-inverting filters in the multiband clipper. Incorrect matching can cause overall frequency response errors because program material other than distortion can be introduced into the distortion-cancel sidechain. If a major cancellation failure occurs, non-flat response at pin 7 of IC5 will be observed in the test above because the output of the distortion-cancel sidechain has already been summed with the main signal at this point. (See **5.d** in **Appendix A** and **Appendix B** for a complete discussion.)

Fig. E-1 shows the two traces superimposed: the upper trace is the output of IC5B and the lower trace is the output of IC6A. This photo was taken from the 5L4N adjusted for a 20-20kHz log sweep and 10dB/division vertical sensitivity. Note that the lower trace (showing the cancellation between the inverting and non-inverting filters) may take any shape. The important thing is that it never rises above -38dB with reference to the upper trace.

Fig. E-1: Main Chain And Distortion-Cancel Sidechain Swept Response in PROOF Mode

5.b) **Distortion-Cancellation Null:** Disconnect the sweep generator from the OPTIMOD-AM input, and connect it to the junction of CR9 and CR10. Observe pin 21 of the card under test (or pin 7 of IC9) with the scope or 5L4N. You should see a trace like Fig. E-2.

Now adjust R65 (DISTORTION CANCEL DEPTH) to deepen the null at approximately 1.4kHz as far as possible. (This trimmer slightly adjusts the gain through the distortion cancel sidechain to match it exactly to the gain of the main 12kHz filter.)

Optionally, you may verify that distortion cancellation is operating properly in the other four top bands by connecting the sweep generator in turn to the junction of CR7/CR8 (Band 5), CR5/CR6 (Band 4), and CR3/CR4 (Band 3), and verifying that the resulting traces resemble Figs. E-3, E-4, and E-5 respectively. (These photos were taken using the 5L4N with a 20-20kHz log sweep and 10dB/division vertical sensitivity.)

E

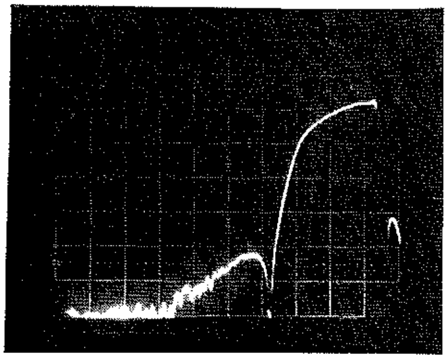

Fig. E-2: Band 6 Distortion Cancellation

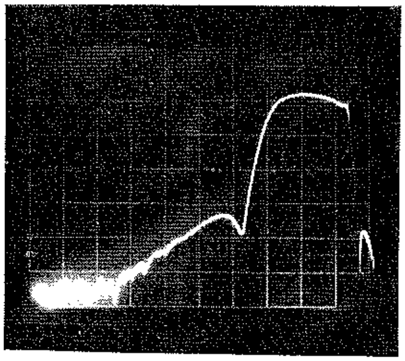

Fig. E-3: Band 5 Distortion Cancellation

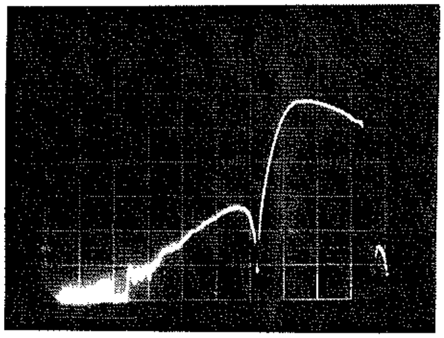

Fig. E-4: Band 4 Distortion Cancellation

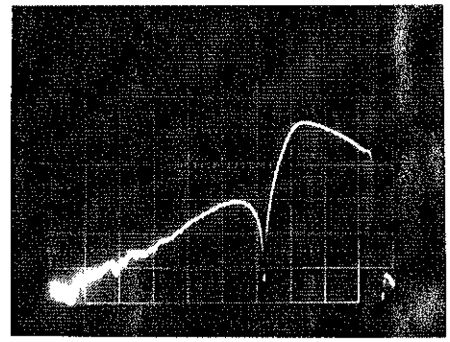

Fig. E-5: Band 3 Distortion Cancellation

5.c) Separation Null (Card #10 Only):

(This step applies to stereo units only.)

The adjustment of R58 (SEPARATION TRIM) is not required if the alignment of the L-R VCA's in procedure **(e)** of 4 above has been carried out in the course of this Complete Field Alignment. The purpose of this trimmer is to provide a means to achieve a quick overall separation null upon stereo conversion of an existing mono OPTIMOD-AM in the field.

For reference, it should be stated that the procedure for adjusting R58 is identical to that described in procedure **(e)** of 4 above, except that only one trimmer is adjusted to maximize separation, and that Card #10 must be extended to access it. In both cases, the OPTIMOD-AM L Input is excited with the sweep generator, Cards #8 and #9 are strapped for L/R operation, the OPTIMOD-AM R Output is observed, and the trimmer(s) adjusted to minimize the R output.

6) OPTIONAL Card #1-S Alignment And Performance Tests

6.a) Preparation: Strap Cards #7 and #10 to the LP FILTER IN position (where they should be already if Card #1-S has been in use). Extend Card #1-S.

6.b) DC Reference Verification And PROOF Mode Test: Set the PROOF/OP switch to OP, and set the POS PEAK THRESH control to "100%" (fully CCW). Measure the voltages on the anode of CR1 and the cathode of CR2, and verify that they are -4.1VDC and +4.1VDC respectively, $\pm$10%.

Then switch the PROOF/OP switch to PROOF, and verify that these voltages are approximately -14VDC and +14VDC respectively. Verify that the voltage at the junction of R67 and R68 is approximately -13VDC.

6.c) Separation Trim And FET Bias: Set both L and R EQ switches OUT. Make sure that the system is still in PROOF mode. Set jumpers "A" and "B" on Card #1-S to the OUT positions. Set jumpers "C" and "D" to the IN positions. Set jumper "E" to the 12kHz ALL TIMES position.

Strap at least one pair of output amplifiers (on Cards #8 and #9) in the L/R mode. (See **Option 2** in **Part 3** of this manual.)

Connect the output of the sweep generator or 5L4N tracking generator to the L OPTIMOD-AM input. Adjust the OPTIMOD-AM L INPUT ATTEN and/or the output level of the sweep generator to produce a reading of approximately -6VU on the OPTIMOD-AM VU meter in L AGC mode. Set the OPTIMOD-AM L DENSITY control to produce -6VU on the VU meter in the L+R 12kHz FILTER mode. Sweep logarithmically from 20-20kHz.

Connect the 5L4N input to pin 7 of IC5b on Card #1-S. (This represents a right-only signal.) Turn R48 (FET BIAS) fully counterclockwise (CCW). Turn R85 (STEREO ENHANCE) fully CCW. Adjust R54 (SEPARATION TRIM) to achieve a null in the swept response, representing minimum crosstalk from L into R.

Now turn R48 fully CW. Separation will deteriorate markedly because the FET is in conduction and is causing gain reduction in the L-R channel. Then slowly turn R48 counterclockwise until separation no longer increases. Go slightly (10 degrees or so) further for safety.

When this adjustment is completed, separation should exceed 25dB from 50-10kHz. The reference level for the separation measurement is found at pin 7 of IC8b.

Then excite the OPTIMOD-AM R INPUT with the sweep generator and, using the same test points as above in inverted sequence, measure R into L crosstalk to make sure that it also exceeds -25dB, 50-10kHz.

6.d) **200Hz Highpass Filter Tests:** Without otherwise changing the test setup, move jumpers "A" and "B" to the IN position. Verify that R into L separation is reduced to approximately 0dB below 190Hz, and that the separation from 200-10kHz is -25dB or better. Then reconnect the sweep generator to the OPTIMOD-AM L INPUT, and repeat the test, measuring L into R crosstalk and verifying that the same conditions are fulfilled. Upon completion of the test, move jumpers "A" and "B" back to the OUT position.

6.e) **5kHz Lowpass Filter Response:** Without otherwise changing the test conditions, observe pin 7 of IC8b and verify that response is flat $\pm$1dB to 12kHz. Then move jumper "E" to the 5kHz ALL TIMES position and verify that the response is now flat to 5.0kHz $\pm$1.0dB, and rolls off with a slope of greater than 30dB/octave thereafter.

Observe pin 7 of IC5b (right channel) and verify that the level is at least 25dB below the level of the desired channel, 50-5kHz. This verifies phase-matching between the L+R and L-R lowpass filters.

Now move jumper "E" to the 5kHz NIGHT position, and verify that the lowpass filter is switched IN when the mainframe logic is in NIGHT mode, and is switched OUT when the mainframe logic is in DAY mode.

Move the sweep generator to the OPTIMOD-AM R INPUT. Observe pin 7 of IC5b and repeat the lowpass filter tests above.

When you are finished, return jumper "E" to the 12kHz ALL TIMES position.

E

6.f) Verification Of Output Matrix And System Separation Trim: Adjust the OPTIMOD-AM R OUTPUT ATTEN on the output (TX1 or TX2) which you have chosen to strap in L/R mode until the VU meter reads "-6" in the appropriate OUTPUT position. Then move the sweep generator to the OPTIMOD-AM L INPUT, and adjust the appropriate OPTIMOD-AM L OUTPUT ATTEN similarly.

Measure the swept response between the appropriate L (+) OUTPUT and ground to establish a reference level. Now measure the crosstalk to the R (+) OUTPUT, and verify that separation exceeds -25dB, 50-10kHz. If you wish, you may extend Card #10 and adjust R58 (SEPARATION TRIM) to null the crosstalk.

Then excite the OPTIMOD-AM R INPUT with the sweep generator and measure R into L crosstalk, verifying that it is also better than -25dB, 50-10kHz.

6.g) Operate-Mode Tests: Connect a pink noise generator to the OPTIMOD-AM L and R INPUTS in parallel. Set the PROOF/OP switch to OP, and adjust the output level of the pink noise generator to produce a reading of "0" on the BROADBAND AGC G/R meter.

Verify that the POS PEAK THRESH control is set to "100%". Using a x10 (10 megohm) probe on the scope, observe the waveforms at the cathodes of CR7 and CR11. (These are the single-channel clipper diodes.) The waveforms should be visibly and symmetrically clipped. Mentally note the clipping levels on the scope: they represent 50% single-channel modulation.

Observe the control voltage across C24, and verify that it is a steady negative voltage, representing the quiescent FET bias voltage: no L-R G/R is being produced in this pure L+R case.

Now disconnect the noise generator from the OPTIMOD-AM R INPUT. After a few seconds, the waveform at the cathode of CR7 should increase in level. The negative side should be clipped at 1.5x the level observed above (i.e., 75% modulation), and the positive side should be clipped slightly above this level. The 75% modulation limit is produced by the clipping action of CR7, while the other limits are produced by the L+R clippers (CR1, CR2) and L-R clippers (CR12, CR13), which clip symmetrically ahead of CR7. The control loop introduces enough L-R G/R to prevent CR7 from clipping more than a few percent. Thus symmetry is largely maintained despite the asymmetrical clipping action of CR7.

Observe the control voltage across C24 once again, and verify that it is now highly active, with voltage variations reaching almost 0VDC. This verifies the operation of the L-R limiter under L-only conditions.

Now drive the OPTIMOD-AM R INPUT only with the noise generator. Observe the cathode of CR11 for the same effects as were observed above. Verify that the control voltage across C24 is highly active and is essentially the same as it was in the L-only case.

This concludes the **Field Alignment.** Return all jumpers to their original positions, all cards to their slots, and all setup controls to their original positions before reinstalling the chassis.

Appendix F:
Trouble Diagnosis and Correction

This Appendix is the first place you should go to obtain information on what to do if OPTIMOD-AM develops a fault.

Many problems experienced in the field can be resolved or conclusively diagnosed with the following diagnostic routines. Even if the repair cannot be done in the field, the information provided by these diagnostic routines can speed the work of the factory service department in making the repair. Please perform these routines and make notes if you observe anything exceptional or unusual.

1) Use systematic troubleshooting techniques to positively determine that the problem is in fact being caused by OPTIMOD-AM and not by other equipment. If a standby processor is available, it should be substituted for the supposedly faulty unit to see if the problem vanishes. If a standby processor is not available, audio quality at the OPTIMOD-AM audio input terminals should be checked with a high-quality monitor system. Note that even slight distortion can be seriously exaggerated by "heavy" processing and that this sort of processing can only be successful if the input audio is extremely clean. A relatively minor problem which develops in the station's audio chain or STL can therefore be magnified by the action of OPTIMOD-AM, even if the unit is in no way defective.

   If the audio is clean going into OPTIMOD-AM, problems can still arise in the transmitter and/or stereo exciter (if used). If a standby transmitter is available, it should be substituted to see if the problem vanishes. If no standby transmitter is available, you can connect the audio output of OPTIMOD-AM through the Monitor Rolloff Filter into a high-quality amplifier and loudspeaker to see if the problem can still be heard. If the problem vanishes when you observe the output of OPTIMOD-AM directly in this way, then the transmitter (or phase-linear STL, if used) is strongly suspect.

   Changes in or deterioration of grounding and/or exterior lead dress can sometimes cause RFI or hum problems to appear in a correctly-operating OPTIMOD-AM.

   If it seems impossible to conclusively isolate the problem to OPTIMOD-AM, yet no other definite cause is found, then performing the **Field Audit Of Performance** procedure in **Appendix D** may help diagnose the problem.

2) Refer to the **Catalog of Typical Symptoms and Probable Causes** below in this **Appendix** to see if your problem is listed. The **Catalog** cannot exhaustively list every potential cause of a given problem. Therefore, you may have to perform the **Problem Localization Routine** below even if you find your symptom in the **Catalog.**

3) If the fault has been positively isolated to OPTIMOD-AM, the **Problem Localization Routine** described below should be performed to identify the faulty PC card.

   But first...

-- Have the control settings been altered?
-- Have phone lines, patch bays, or other station wiring been recently maintained or altered?

PROBLEM LOCALIZATION ROUTINE

The most powerful and general technique for localizing a problem within OPTIMOD-AM is signal tracing. This simply means that the signal is observed at various points as it passes from OPTIMOD-AM's input to its output. If the signal is normal at some point "A" in the circuit and is abnormal at a point "B" further towards the output, then the problem clearly lies in circuitry between points "A" and "B".

Signal tracing in a stereo OPTIMOD-AM is facilitated by the fact that much of the circuitry is duplicated and is arranged so that the bad channel can be readily compared with the good one, which serves as a "normal" reference.

POWER SUPPLY TESTS

Some circuitry is common to both channels and failures will therefore affect both channels in a symmetrical way. In particular, problems in the power supply may affect many circuits simultaneously. For this reason, the first step in any troubleshooting procedure is to check the power supply for normal output. Gross changes in power supply voltage can be detected with the "+15VDC" and "-15VDC" positions on the VU meter. Normal readings are 0VU ±0.5VU. If normal readings are obtained, skip to the next section on **VU Meter Techniques.**

If either "+" or "-" power supply output is significantly low, it could indicate a defect in the supply itself. But it is more likely to indicate a shorted IC or capacitor somewhere in the circuit that is overloading the supply and causing it to current-limit.

The power supply is electronically protected against excessive current demand by other parts of the circuitry. If a failure causes a high current demand on the power supply, its output voltage will drop as far as necessary to reduce output current to approximately 0.75A. If the power supply voltage is observed to be abnormally low, unplug each circuit card in turn and check if the power supply recovers by observing the "-15VDC" meter position. (The negative regulator tracks the +15V supply. So the -15V supply will go down if the +15V supply does, even if the -15V supply or load is completely normal. A normal "-15VDC" reading thus assures a normal "+15VDC" reading.) If recovery occurs, then troubleshoot the unplugged board. Ordinarily, the defective component will become very hot, and is easily detected by touch. (Wet your finger first to avoid burns!)

If all cards are removed and an undervoltage problem does not disappear, examine the meter card, motherboard, and chassis wiring before suspecting the supply itself. (A wiring problem will be indicated by an ohmmeter's indicating very low resistance between the "+15V" or "-15V" power buses with AC power OFF.)

Even if power supply voltages appear normal on the VU meter, subtle problems such as hum, noise, or oscillation may still exist with the supply. To check for this, test the regulated DC with a well-calibrated DVM, scope, and AC VTVM with 20-20kHz bandpass filter. Voltages should be +15.00V ±0.075V, and -15.00V ±0.375V. Ripple must be less than 2mV r.m.s., 20-20,000Hz. There must be no high frequency oscillation.

VU METER TECHNIQUE If one channel goes dead, the VU meter provides a means for fast signal tracing. Note, however, that problems other than gross gain changes or total failure to pass signal may not be detected by the meter alone.

Because the VU meter selector switch does not permit dividing the system into sufficiently small parts to perform an unambiguous diagnosis of most problems at the card level, it is usually necessary to use the **Card Swap Technique** (below) to localize the problem more precisely.

The instructions for the **Card Swap Technique** provide more detailed information on troubleshooting at the "card exchange" level. Servicing on the "component replacement" level requires more profound understanding of OPTIMOD-AM circuit operation, which is provided by **Appendix** A (**SYSTEM DESCRIPTION)** and **Appendix** B (**CIRCUIT DESCRIPTION).** If the technician wishes to troubleshoot at the component level, he should first use **Appendix** A to help track down the fault to a given subsystem, and then refer to **Appendix B** for an extremely detailed explanation of the circuitry at the component level.

In the case of no signal or very low-level signal, switch through the first ten VU meter functions (which monitor the audio processing) to see where the signal disappears (or the VU meter pegs, implying that a defective IC opamp has latched to the power supply rail.) In mono units, the "L-R" and "R" positions will not indicate.

Refer to the block diagram in **Appendix J** to locate the exact points in the signal path monitored by the meter. This diagram will usually suggest which of the cards is defective.

If the signal is normal at the input terminals and abnormal in either AGC position then the problem lies with the Input Buffer or Input Conditioning Filter in Card #4 (left channel) or Card #5 (right channel), or with the Broadband VCA circuitry on Card #2. Defective control circuitry (on Card #6) affecting the Broadband VCA will be indicated by the Broadband AGC G/R meter's indicating other than "0" under no-signal or PROOF conditions.

If the signal is normal at the AGC positions but is abnormal in the MATRIX positions, then the problem probably lies in the Program Equalizer circuitry on Card #4 (left channel) or Card #5 (right channel).

If the signal is normal at the MATRIX positions but is abnormal in either 12 KHZ FILTER position, then the problem may lie with the Pre-Compressor crossovers on Card #4 (L+R or mono) or Card #5 (L-R: stereo units only), with the Six-Band Limiter VCA's on Cards #2 and #3, with the circuitry on Cards #7 (L+R or mono) or #10 (L-R: stereo only), or with the optional #1-S Card (which is common to both channels.)

If the signal is normal at both 12KHZ FILTER OUT positions but is abnormal at any of the TX OUT positions, then the problem lies in the Safety Clipper and Supersonic Lowpass Filter circuitry on Cards #7 (L+R or mono) and #10 (L-R: stereo only), or in Cards #8 (L+R, L, or mono) and #9 (L-R or R).

Once the general area is located, the **Card Swap Technique** can often identify the specific card.

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CARD SWAP TECHNIQUE

If the defective card has not yet been conclusively identified, the **Card Swap Technique** may be useful in diagnosing problems, particularly in stereo units. Certain defects in mono units can also be diagnosed, but often other means discussed later must also be employed.

Card swapping is an analysis technique only -- the unit will not operate properly unless cards are installed in their normal slots in sequential order.

IMPORTANT!

REMOVE POWER FROM THE CHASSIS BEFORE REMOVING OR INSTALLING CARDS.

Appendix C provides instructions on obtaining access to the cards.

-- First perform the VU meter diagnostic technique (as described above) to generally localize the problem if possible.

1) VCA's And Compressor/Limiter Control Circuitry (Mono Or Stereo Units)

This procedure is useful in diagnosing faults in the voltage-controlled amplifiers on Cards #2 and #3. It is particularly valuable in troubleshooting a problem characterized by any of the G/R meters' behaving abnormally (i.e., staying at "0" or pegging in the red section of the scale). The procedure will determine if the problem is in the VCA's (Cards #2 and #3) or in the control circuitry (Card #6).

If the broadband AGC will not operate at all, check the position of jumper "A" on Card #6, referring to **Initialization Option 6: Broadband AGC Defeat** in **Installation (Part 3).**

If one or more G/R meters pegs in the red, this can indicate a "latchup" condition. A latchup can occur if the power supply turns on in an abnormal way and could be caused by a very short power failure. Its most common cause is insertion of a card into its slot with the chassis powered. Latchups are non-destructive and are cleared by removing power from the chassis for a few seconds and then restoring it. But avoid installing cards with the power on.

Swap Cards #2 and #3. If the problem moves from left to right or vice-versa (as observed at the OPTIMOD-AM output or on your stereo monitor) then the problem is in one of the Broadband VCA's on Card #2. (**NOTE:** Early units with serial numbers below 540000 have not been equipped with wiring to interchange the L and R Broadband VCA's when Cards #2 and #3 are swapped. In these units the above Broadband VCA test is not conclusive. The test is conclusive in all units with serial numbers from 540000 up.)

If the problem was observed in the Six-Band Limiter, find out if the problem moves to a different band when the cards are swapped. If it moves from Band 1, 3, or 5 (150, 700, 3700Hz) to Band 2, 4, or 6 (420, 1600, 6200Hz) then the problem is in Card #2. If it moves from Band 2, 4, or 6 to Band 1, 3, or 5 then the problem is in Card #3.

If the problem stays in the same band, then Card #6 (control circuitry for all bands) is the probable cause.

It is important to note that, due to higher gain in the Band 6 VCA on Card #3, normal flat frequency response will not be achieved when Cards #2 and #3 are swapped. When the cards are swapped, it is normal for the 3.7kHz response to be elevated 5dB and for the 6.2kHz response to be depressed 5dB.

If the problem has not yet been diagnosed, return Cards #2 and #3 to their slots and continue to (2) below.

2) **Optional Stereo Enhance Card #1-S (Stereo Or Mono Units)**

If Card #1-S is not installed, go to step (3).

If this optional card is installed, remove Cards #7 and #10 (stereo only) from their slots. To bypass Card #1-S, restrap jumper "A" in each card to the OUT position, referring to the Card #7/10 schematic diagram in **Appendix J.** Then reinstall the cards.

Remove Card #1-S from its slot. Power the chassis, and see if the problem has vanished. If so, Card #1-S is defective. If you wish, the unit can be operated without this card on an emergency basis until repairs can be made.

If the problem did not vanish, restrap jumper "A" on the #7 and #10 Cards IN, and reinstall all cards in their slots.

IF YOU HAVE A MONO UNIT, NO OTHER CARD-SWAPPING TECHNIQUES ARE AVAILABLE. GO TO **MONO TECHNIQUES** BELOW.

If you have a stereo unit, continue to (3) below.

3) **Preparation For Further Card-Swapping (Stereo Units Only)**

The 9100A carries the signal in both L/R and L+R/L-R forms in various parts of its circuitry. This would make unambiguous identification of faults by further card-swapping difficult. To avoid this difficulty, the entire OPTIMOD-AM system is temporarily strapped for L/R operation throughout the signal path prior to further card swapping. This is a special test mode used only for troubleshooting. IN THIS MODE, THE SIX-BAND LIMITER CONTROL CIRCUITRY (WHICH CAUSES GAIN REDUCTION) WILL BE ACTIVATED BY LEFT CHANNEL SIGNALS ONLY.

To enter the special test mode, first remove Cards #4 and #5. Noting how the stereo/mono jumpers were strapped (for restoration later), move both jumpers to the MONO position. (Refer to the Card #4 and #5 schematic diagrams in **Appendix J.** These diagrams show diagrams of the jumpers, marked "A" on both the cards and the schematics.)

Then remove IC10 on Card #5 from its socket, referring to the Card #5 assembly drawing in **Appendix J.** This defeats the matrix circuit.

Reinstall Cards #4 and #5 in their slots.

Remove Cards #8 and #9 from their slots. Noting how jumpers "C" and "D" were strapped, restrap Card #8 for L+R operation and Card #9 for L-R operation, bypassing the dematrix. (Because the first matrix has been removed, this corresponds to "L" and "R" operation in this special test mode.)

Reinstall Cards #8 and #9 in their slots.

Power the chassis and see if a problem is still observed. If the problem has vanished, there are several possibilities:

a) The problem is in the matrix or dematrix circuitry. This is highly improbable because these circuits are extremely simple. If this is the problem, then replacing IC10 on Card #5 or IC3 on card #9 should solve it unless it is extremely obscure (involving, for example, resistor, jumper, socket, or motherboard failure).

b) The problem involves a failure to achieve adequate channel separation due to relatively small mismatches between L+R and L-R circuitry. Such problems will ordinarily translate, in the special card-swap test mode, to relatively small deviations from flat frequency response in the defective channel. (0.3dB mismatch causes no better than 30dB separation; 1.0dB mismatch causes no better than 20dB separation.) Careful measurements of frequency response must therefore be made, comparing the two channels to determine which one exhibits the flattest frequency response. The swapping technique can determine which card causes the unflat response by treating the unflat response as the "problem" as the procedure below is followed.

   A mismatch that will not manifest itself as a frequency response error is a phase error in any phase corrector on Cards #7 or #10. This problem can be diagnosed by performing procedure **(5.b) (Distortion Cancellation Null)** in **Appendix E.** (A faulty phase corrector will prevent distortion cancellation from occurring.)

c) The problem is intermittent, and the physical shock involved in moving the cards has temporarily repaired it. Diagnosis of intermittents is usually tricky and is best left to experienced technicians or to the factory.

4) Card #4 and #5 Swap (Stereo Units Only)

If the problem appears only when the EQ IN/OUT switch for a given card is IN, then that card is probably faulty.

Swap Cards #4 and #5 in their slots. If the problem moves from left to right, card #4 is faulty. If the problem moves from right to left, card #5 is faulty.

If the problem does not move, reinstall Cards #4 and #5 in their correct slots and move to (5) below.

5) Card #7 and #10 Swap (Stereo Units Only)

Swap Cards #7 and #10 in their slots. If the problem moves from left to right, Card #7 is faulty. If the problem moves from right to left, Card #10 is faulty.

Note that Card #7 contains circuitry to bias the clipper diodes in both Cards #7 and #10. If this circuitry is faulty, there will be no movement of fault when Cards #7 and #10 are swapped. However, both channels will tend to exhibit an identical problem.

This may be confirmed by measurement of the ±1.8V and ±4.1V bias supplies. To do this, extend Card #7 using the card extender supplied. Then (temporarily) set the POS PEAK THRESH control to 100% and, using a well-calibrated voltmeter, verify that pin 1 of IC7 (or finger V of the card edge connector) exhibits +4.1VDC, pin 7 of IC7 (or finger 18 of the card edge connector) exhibits -4.1VDC, pin 1 of IC8 (or finger W of the card edge connector) exhibits +1.8VDC, and pin 7 of IC8 (or finger 19 of the card edge connector) exhibits -1.8VDC, all with respect to circuit ground (which will ordinarily be present on the chassis unless circuits and chassis grounds have been unlinked at the rear-panel barrier strip). Unless the problem is extremely subtle, these supplies can be considered to be operating correctly if the measured voltages are within ±10% of nominal.

If no problem has been found yet, return Cards #7 and #10 to their slots and continue to (6) below.

6) Card #8 and #9 Swap (Stereo Units Only)

If the problem is observed in the left channel only when the TX EQ switch in IN, Card #8 is faulty. If the same occurs in the right channel, Card #9 is faulty. If the problem occurs regardless of the position of the TX EQ switch, continue on.

With the TX EQ switch in the position ordinarily used in your installation, swap Cards #8 and #9. If the problem moves from left to right, card #8 is faulty. If the problem moves from right to left, Card #9 is faulty.

If the DAY/NIGHT and/or TX1/TX2 switching is faulty, the problem is probably in Card #8 unless there are interconnect problems, problems on the meter resistor card, or problems inside the RFI filter box on the rear of the chassis.

If the problem is still not found, return Cards #8 and #9 to their slots and continue to (7) below.

7) Signal Tracing

If you have come this far without finding the problem, you must use more detailed and traditional signal tracing procedures. Refer to the Block Diagram and schematic diagrams in **Appendix** J, and to the **System Description (Appendix** A) for help.

8) Restoring Things To Normal

When you have finished the troubleshooting procedure, restore the jumpers moved in (3) above to their normal positions. Replace IC10 in Card #5, carefully aligning the notched or dotted end of the IC with the end of the circuit card pads showing a small flag or protrusion.

CAUTION!

If the IC is inserted backwards, it will be instantly destroyed when the chassis is powered!

This concludes the **Card Swap Procedure.**

MONO TECHNIQUES If you have already performed steps 1 and (optionally) 2 of the **Card Swap Technique** section above and have not yet diagnosed your problem, you should refer to this section.

1) Switch the EQ IN/OUT switch on card #4 OUT, and see if the problem vanishes. If so, the problem is probably with Card #4.

2) Switch the TX EQ IN/OUT switch OUT and see if the problem vanishes. If so, the problem is probably with Card #8.

3) Problems associated with the DAY/NIGHT and TX1/TX2 switching on the front panel are almost certainly associated with Card #8.

4) Failure to control modulation tightly is probably due to Card #7. This must be verified by switching the TX EQ IN/OUT switch OUT and observing the output of OPTIMOD-AM directly with a DC-coupled scope. The output waveform should be quite clipped. Both positive and negative peak levels should be very consistent and tightly controlled. If this is the case, yet peaks as read on your monitor are inconsistent, suspect problems with the transmitter or monitor. See **Various Application Notes (Part 2)** for a complete discussion.

5) At this point, it is wise to trace the signal through the OPTIMOD-AM system using an amplifier (to listen subjectively for problems using program material as the test signal), or using a signal generator and scope and/or distortion analyzer (to obtain more quantitative measurements). If you use the signal generator, be sure that the problem can be measured at the OPTIMOD-AM output using sinewave excitation.

   You should observe the signal as it flows through OPTIMOD-AM from input to output. If the signal is normal at some point "A" in the circuit and is abnormal at a point "B" further towards the output, then the problem clearly lies in circuitry between points "A" and "B".

   The **Block Diagram** in **Appendix** J provides a "road map" through the OPTIMOD-AM system. Use it in conjunction with the schematic diagrams of the cards (also in **Appendix J**) to identify the outputs of the various blocks in the **Block Diagram.** The outputs of these blocks should be observed sequentially in the course of signal tracing.

   In general terms, the signal flows through OPTIMOD-AM as follows:

   Card#4->Card#2->Card#4->Cards#2&#3->Card#7->Card#8. Card #6 is a control card and does not pass signal.

   If you have followed step (1) of the **Card Swap Technique** above, you have reduced the probability that the problem lies with Cards #2, #3, or #6. You should therefore concentrate on the remaining cards. In any event, use the **CATALOG OF SYMPTOMS AND PROBABLE CAUSES** below to suggest which areas of the circuitry are most suspect.

CATALOG OF TYPICAL SYMPTOMS AND PROBABLE CAUSES

This troubleshooting guide is a catalog of some possible defects in a system containing OPTIMOD-AM. If the problem seems to reside in OPTIMOD-AM, it can be used in conjunction with **Appendices** A and B to aid troubleshooting at the component level.

ALWAYS BE SURE THAT THE PROBLEM IS NOT IN THE SOURCE MATERIAL FEEDING OPTIMOD-AM OR IN OTHER PARTS OF THE SYSTEM.

--Problems with subjective sound quality, particularly problems not clearly indentifiable as simple electronics failures.

1) Review the **CATALOG OF OPERATING OBJECTIVES AND SOLUTIONS** at the end of **Operating Instructions (Part 5)** to make sure that it isn't a simple setup problem.

--Whistle is heard on air.

1) Power supply oscillation. Suspect C111, C112, IC101, IC102.
2) Whistle on one stereo channel only (or in L+R or L-R only) probably due to oscillating IC. Use signal tracing techniques to isolate defective IC.

--Buzz or hum.

1) Improper grounding. Chassis not properly grounded to rack or rack to earth. Circuit and chassis grounds connected through excessively long path. No direct connection between OPTIMOD-AM circuit ground and circuit ground of transmitter or exciter with balanced input.
2) RFI. Improve grounding scheme. Relocate OPTIMOD-AM chassis. Change length of input or output cables to retune them.
3) Low line voltage causing regulator to drop out and pass ripple.
4) C101, C102 in unregulated power supply failed, resulting in extremely high ripple. Power supply regulator drops out on each ripple cycle which instantaneously goes lower than 17.5 volts. (See **Power Supply Tests** in **PROBLEM LOCALIZATION ROUTINE** above.)

--Loss of modulation control.

1) Make sure SAFETY CLIPPER DEFEAT jumper on Card #7 is in OPERATING position.
2) Check for tightly-controlled peak levels at processor output when Cards #8 and #9 are strapped for L+R/L-R operation. (It is normal for L and R outputs to show peak level variation because of sum-and-difference processing.) If levels not well-controlled, check $\pm$4.1V supply on Card #7.
3) If levels are well-controlled, check connection to transmitter or exciter, including STL (if used). Inadequate phase linearity and/or frequency response in the circuit path <u>after</u> OPTIMOD-AM can change peak levels, causing overshoots and loss of modulation control. This problem will ordinarily appear immediately upon installation.
4) Make sure PROOF/OPERATE switch is in OPERATE.

--Output frequency balance doesn't sound like input.

1) It's not supposed to. The thresholds of the Six-Band Limiter have been adjusted to provide dynamic high frequency boost even if no HF EQ is used. If HF EQ is used, further HF boosting will occur. Even if you listen through the Monitor Rolloff Filter, the Six-Band Limiter will still tend to act as an "automatic equalizer", dynamically changing the frequency balance of program material to make it more pleasing and more intelligible on a typical AM radio.

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2) The available bass boost is limited dynamically to prevent bass from overdriving the safety clippers, thus avoiding excessive IM distortion. While OPTIMOD-AM is capable of producing punchy, well-defined bass which sounds correct and is musically balanced, highly exaggerated bass boost cannot be obtained.

--Voice too loud.

1) 9100A processing normally has a tendency to make voice somewhat louder than music. If a balance favoring music is desired, train the operators to peak voice <u>lower</u> than music on the console meters.

--Insufficient high frequency response.

1) The 9100A's HF equalizer has purposely been limited in range to be less than that of the old 9000A. Many tests have led us to believe that the 9100A is capable of as much HF boost as can be practically used with current AM radios. Further HF boost (beyond that obtainable with the 9100A's HF EQ control) will cause radios to become unacceptably difficult to tune, and will increase distortion to disturbing levels.
2) Inadequate antenna bandwidth can cause this problem. In this case, there will often be high frequency distortion as well. [See **Antenna System** in **Various Application Notes (Part 2).]**

--Gross distortion. (See also next sections.)

1) Power supply voltage low. (Check AC power line voltage first.)
2) IC opamp failure. This must be diagnosed by signal tracing.
3) Failure in clipper-diode bias supplies on Card #7. Low bias voltage will cause excessive clipping and will also result in abnormally low modulation. Check IC7, IC8 and associated circuitry (on Card #7) to make sure that the output from IC7 is approximately ±4.1VDC when the POSITIVE PEAK THRESH control is at 100%. Check IC8 and associated circuitry to make sure that the output is approximately ±1.8VDC under the same condition.
4) Gross failure of IC6 on Card #7 and/or Card #10. This will either misbias the main signal path or add distortion to the main signal without causing the main signal to disappear.
5) Failure of one or more bands in the Six-Band Limiter such that distortion is injected into the signal path from the defective band. Because other bands are still operating normally, signal passage will still occur [although with strange frequency response due to the missing band(s)]. Faults can occur in the Pre-Compressor Crossovers (on Cards #4 and #5), in the VCA's (on Cards #2 and #3), and in the Post-Compressor Crossover/Multiband Clipper on Cards #7 and #10.

--Moderate to subtle distortion.

1) Distorted program material and/or distortion problems in studio or STL (see **Appendix** K for further discussion).
2) Check points listed in "Gross Distortion" (immediately above), for moderate deviations from normal parameters.
3) CLIPPING control misadjusted.
4) Failure in Card #6 (control card), such that one or more bands is producing modulation control solely by multiband clipping. This is usually indicated by the G/R meter of the affected band's reading "0" at all times.

5) Failure in distortion-cancelling sidechain on Cards #7 and #10. This is typically indicated by a "gritty" high end with severe sibilance splatter.
6) Problems in the transmitter and/or antenna system, such as saturation of the modulation transformer due to heavy use of OPTIMOD-AM's transmitter equalizer, inadequate power supply, antenna asymmetry, or narrowband antenna. A full discussion is found in **Various Application Notes (Part 2).**

--Sibilance distortion.
1) Source material at OPTIMOD-AM input terminals distorted.
2) Failure of distortion-cancelling sidechain on Cards #7 or #10.
3) Failure of the control circuitry in Band 6 (6.2kHz). If Band 6 is exhibiting no gain reduction, then even a properly-operating distortion-cancelling clipper may generate some audible distortion.

--Inadequate separation
1) This is usually caused by a mismatch between the circuitry carrying the sum (L+R) and difference (L-R) channels. This circuitry is complex, containing sophisticated filters whose phase and amplitude must match, plus VCA's whose gains must track dynamically. While 30dB dynamic separation is typically achievable, please note that the guaranteed separation is less. A more complete discussion is found in **Maintenance (Part 7).**
2) The POS PEAK THRESH control is being operated beyond 100% positive, causing distorted right-into-left crosstalk because of asymmetries introduced between the sum and difference channels. See **Stereo And Asymmetry** in **Various Application Notes (Part 2).**
3) Drift or failure in the stereo exciter or transmitter.
4) Narrowband antenna system.
5) If the Single-Channel Limiter/Stereo Enhance circuit on the optional Card #1-S is strapped IN and an attempt is made to measure separation by driving only one channel in OPERATE mode, this circuit will normally dynamically reduce separation because single-channel excitation is almost never found in normal program material, yet the circuit must limit single-channel modulation to -75% to prevent distortion in receivers even in this unusual situation. When program material with normal amounts of separation is processed, full separation is preserved.

--Inadequate modulation of tones in EBS test.
1) This is normal. Ordinarily, EBS tones must be introduced through the Auxiliary Input. See **Two-Tone EBS Tests** in **Various Application Notes (Part 2).**

FACTORY ASSISTANCE

Orban Associates Inc., maintains a Customer Service Department to help Orban product users who experience difficulties. Orban Customer Service is supplied at two levels. The first is telephone consultation. Often, a problem is due to misunderstanding or is relatively simple and can be fixed by the customer aided by phone advice from the factory. Second is factory service.

First read the **Catalog Of Typical Symptoms And Probable Causes** above. If the problem is still undiagnosed after this is done, perform the **Problem Localization Routine** above.

Telephone consultation should always be the next step in seeking assistance. (Our Customer Service Engineers need the information you obtain in the **Problem Localization Routine** to help you.)

Before calling Customer Service, be prepared to give the model number [9100A/1 (mono) or 9100A/2 (stereo -- whether field- or factory-installed)] and serial number of your unit. If the unit is in its warranty period and the Registration Card was not returned, we may also need the name of the dealer from which the unit was bought, the invoice number, and the invoice date if warranty service is desired.

Be prepared to accurately describe the the problem. What is the complaint? Is it constant or intermittent? If it is intermittent, can it be correlated to environmental conditions like line voltage, temperature, humidity, electrical storms, vibration, etc? Do problems only occur with certain program material (live voice, very bright music, music with heavy bass transients, etc.)? What about source: network, cart, reel-to-reel tape, live microphone, remotes, phone lines?

Be prepared to describe any unusual observations made during the **Problem Localization Routine** you performed using the instructions above.

Then, contact the Customer Service Department by telephone, letter, or Telex (see title page for numbers). A Customer Service Engineer is ordinarily available during local business hours, Monday through Friday. The Customer Service Engineer will do everything practical to help you correct the fault and have your OPTIMOD-AM up and running again as quickly as possible.

In many cases, field repairs can be effected by merely exchanging a single PC card rather than by returning the entire OPTIMOD-AM chassis for repair. The factory ordinarily maintains a small number of "loaner cards". One of these may be provided as a spare PC card for use while your card is being repaired at the factory. In most cases, factory service of defective cards is preferable to field service because the factory maintains a supply of exact-replacement spare parts and has the experienced technicians and special test fixtures necessary to assure that the repaired card meets factory specifications in all respects. Instructions for packing and shipping cards or the complete chassis are found at the end of this Appendix.

Units will be accepted for factory service (the second level) only after consultation and only after a Return Authorization (RA) code number has been provided by phone or letter. The RA number flags the returned unit for priority treatment when it arrives on our dock and ties it to the appropriate information file.

The purpose of these procedures is to save both the customer and the factory time and trouble by attempting to weed out problems which are caused by equipment other than OPTIMOD-AM, misapplication, or environment, and to identify those problems that lend themselves to quick field repair.

DIAGNOSIS AT THE COMPONENT LEVEL

After following the above diagnostic procedure to localize the problem to a single card, you may want to troubleshoot the card on the component level instead of returning the card to the factory for service.

Here are some suggestions....

Troubleshooting IC Opamps

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

Exceptions are IC's used without feedback (as comparators) and IC's whose outputs have been saturated due to excessive input voltage because of a defect in an earlier stage. However, if an IC's "+" input is more positive than its "-" input, yet the output of the IC is sitting at -14 volts, this almost certainly indicates that it is bad. The same holds if the above polarities are reversed. Because the characteristics of OPTIMOD-AM are essentially independent of IC opamp characteristics, an opamp can usually replaced without need for recalibration.

NOTE

THE DUAL CURRENT-CONTROLLED GAIN BLOCKS EMPLOYED IN THE VCA's ON CARDS #2 AND #3 (IC's 2, 4, 7, 9, 13, 15, 18, & 20) ARE NOT OPAMPS. IF THEY ARE REPLACED, RECALIBRATION IS ABSOLUTELY NECESSARY.

Defective IC's are sometimes very hot to touch (wet your finger!). But overheated IC's can also be caused by defects in their loads. Certain IC's (like the NE5532 and NE5534) normally run quite hot. So it's only a clue.

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

Selecting And Ordering Replacement Parts

Nearly all parts used in Optimod-AM have been very carefully chosen to make best use of both major and subtle characteristics. For this reason, parts should always be replaced with exact duplicates as indicated on the Parts List. It is very risky to make "close-equivalent" substitutions because of the possibility of materially altering performance and/or compliance with FCC requirements. The Factory is ordinarily able to supply any replacement part rapidly at a reasonable price.

Specifically, such parts include all FET's and precision metal-film resistors, almost all capacitors, trimmer resistors, and integrated circuits, most transistors, and certain diodes.

Certain cards contain potted modules which, if diagnosed as defective, must be replaced as a unit. Ordinarily, this requires return of the entire card to the factory for recalibration.

Certain parts are selected by the factory to tighter than normal specifications in order to obtain circuit performance which meets our exacting standards. Such parts are footnoted in the Parts Lists.

Certain parts, if replaced, require partial recalibration which may or may not be practical in the field. Such parts are footnoted in the Parts Lists. The recalibration requirements are outlined in the appropriate section of **Appendix B (Circuit Description)** and/or **Appendix E (Alignment).**

Service in areas involving selected parts or recalibration is best referred to the factory, which, as a result of training, experience, availability of special equipment, and availability of exact replacement parts, is generally far better qualified to perform repairs efficiently and correctly.

F

Ordering Parts From The Factory: If parts are ordered from the factory, we may require any or all of the following information:

-- The Orban part number, if ascertainable from the Parts List
-- The Card on which the part is located (e.g. Card #4)
-- The Reference Designator (e.g., R50)
-- A brief description of the part
-- And, from the serial label on the rear of the unit
  - the exact Model Number
  - the Serial Number
  - the "M" number, if any

Replacement Of Components On Printed Circuit Cards

It is important to use the correct technique for replacing components mounted on PC cards. Failure to do so may result in circuit damage and/or intermittent problems.

Many components, if replaced, will cause a change in calibration which will require returning the affected circuit card to the factory for recalibration. Also, some components are selected for characteristics which are not indicated by the manufacturer's part number. Most of these components are listed as "selected" on the parts list, but not all. In addition, the selection criteria are not generally described. It is therefore almost always wiser to return the defective card to the factory for service.

Most circuit cards used in OPTIMOD-AM are of the double-sided plated-through variety. This means that there are traces on both sides of the card, and that the through-holes contain a metallic plating in order to conduct current through the card. Because of the plated-through holes, solder often creeps 1/16" up into the hole, requiring a sophisticated technique of component removal to prevent serious damage to the card.

If the technician has no practical experience with the elegant and demanding technique of removing components from double-sided PC cards without card damage, it is wiser to cut each of the leads of an offending component from its body while the leads are still soldered into the card. The component is then discarded, and each lead is heated independently and pulled out of the card with a pair of long nose pliers. Each hole may then be cleared of solder by carefully heating with a low-wattage soldering iron and sucking out the remaining solder with a spring-activated desoldering tool. THIS METHOD IS THE ONLY SATISFACTORY METHOD OF CLEARING A PLATED-THROUGH HOLE OF SOLDER IN THE FIELD!

The new component may now be installed by following the directions below starting with step (4).

Otherwise, use the following technique to replace a component:

1) Use a 30 watt soldering iron to melt the solder on the solder side (underneath) of the PC card. Do not use a soldering gun or a high-wattage iron! As soon as the solder is molten, vacuum it away with a spring-actuated desoldering tool like the Edsyn "Soldapullt". AVOID OVERHEATING THE CARD; overheating will almost surely damage the card by causing the conductive foil to separate from the card base.

   Even with care, you are likely to blister the enamel solder-mask coating on the card, which, in most cases, is no cause for concern. The coating exists mainly to prevent moisture from condensing between the traces and to simplify wave-soldering.

2) Repeat step (1) until each lead to be removed has been cleared of solder and freed.

3) Now release the component by gently wiggling each of the leads to break solder webs. Then lift the component out.

4) Bend the leads of the replacement component until they will fit easily into the appropriate PC card holes. Using a good brand of rosin-core solder, solder each lead to the bottom side of the card with a 30 watt soldering iron. Make sure that the joint is smooth and shiny. If no damage has been done to the plated-through hole, soldering of the topside pad is not necessary. However, if the removal procedure did not progress smoothly, it would be prudent to solder each lead at the topside as well in order to avoid potential intermittent problems.

5) Cut each lead of the replacement component close to the solder (underneath) side of the PC card with a pair of diagonal cutters.

6) Remove all residual flux with a cotton swab moistened with a solvent like 1,1,1 trichloroethane, naptha, or 99% isopropyl alcohol. The first two solvents are usually available in supermarkets under the brand name "Energine" fire-proof spot remover and regular spot remover, respectively. The alcohol, which is less effective, is usually available in drug stores. Rubbing alcohol is highly diluted with water and is ineffective.

   It is good policy to make sure that this defluxing operation has actually removed the flux and has not just smeared it so that it is less visible. While most rosin fluxes are not corrosive, they can slowly absorb moisture and become sufficiently conductive to cause progressive deterioration of performance.

Shipping Instructions

Circuit Cards: A circuit card is best shipped in the special Orban Associates shipping carton used to supply loaner cards. If you wish to ship a card without this carton, cut two pieces of 1" or thicker soft foam to 6.5" x 9" (17cm x 23cm) or larger. Sandwich the card between the two foam pieces, and ship the foam "sandwich" in a rigid cardboard carton.

A "JIFFY-BAG" OR SIMILAR SOFT MAILING BAG DOES NOT PROVIDE SUFFICIENT PROTECTION FOR THE CARD, AND MUST NOT BE USED!

Shipping The Complete Chassis: If the original packing material is available, it should be used. Otherwise, a sturdy, double-wall carton of at least 200 pounds bursting test and no smaller than 22" x 15" x 12" (56 x 38 x 31 cm) should be employed.

OPTIMOD-AM should be packed so that there is at least 2" of packing material protecting every point. A plastic wrap or bag around the chassis will protect the finish. Cushioning material such as Air-Cap, Bubble-Pak, foam "popcorn", or thick fibre blankets are acceptable. Folded newspaper is not suitable. Blanket-type materials should be tightly wrapped around OPTIMOD-AM and taped in place to prevent the unit from shifting out of its packing and contacting the walls of the carton.

The carton should be packed evenly and fully with the packing material filling all voids such that the unit cannot shift in the carton. Test for this by closing but not sealing the carton and shaking vigorously. If the unit can be felt or heard to move, use more packing. The carton should be well-sealed with 3" (8 cm) reinforced fibreglass or polyester sealing tape applied across the top and bottom of the carton in an "H" pattern. Narrower or parcel-post type tapes will not stand the stresses applied to commercial shipments.

The package should be marked with the name of the shipper, and the words in red: DELICATE INSTRUMENTS, FRAGILE!. Even so, the freight people will throw the box around as if it were filled with junk. The survival of the unit depends almost solely on the care taken in packing!

After a formal Return Authorization (RA) number is obtained from the factory, units should be shipped to the Service Manager at the address shown on the title page.

YOUR RETURN AUTHORIZATION NUMBER MUST BE SHOWN ON THE LABEL, OR THE PACKAGE WILL NOT BE ACCEPTED!

INSURE YOUR SHIPMENTS APPROPRIATELY!

SHIP PREPAID -- DO NOT SHIP COLLECT!

DO NOT SHIP PARCEL POST!

(Otherwise, have a nice day.)

Appendix G:
Stereo Conversion

GENERAL This **Appendix** provides instructions on converting a mono (9100A/1) to a stereo (9100A/2) unit in the field using the field retrofit kit. This kit consists of three circuit cards: #5, #9, and #10 and other parts. It is ordered as "RET-16".

No wiring changes are required; the unit has been prewired for stereo.

After the unit is converted, it will operate in stereo without further adjustments. However, it may not quite meet our published separation specifications at all frequencies due to unavoidable tolerance buildup in the retrofit cards. (As an example of the tight tolerances involved, 30dB separation requires that the sum and difference channels be matched better than 0.3dB and 3 degrees.) Therefore, a separation optimization touchup alignment procedure is provided. It is recommended that this procedure be performed as part of the conversion. (If the procedure is not performed, the unit will probably meet FCC specifications but the potential separation performance designed into the unit will not be achieved.)

INSTALLATION PROCEDURE (Slots are numbered backwards from #10 on the far right. Card connectors are keyed, but some card pairs have the same keying.)

1) Obtain access to the circuit cards, following the instructions in **Appendix C.** Be sure to turn off AC power before removing or replacing cards. Use caution in removing cards to avoid damage to components. Use the extractor tabs on the cards.

2) Remove Card #4. Move jumper "A" to the STEREO position according to the diagram below. Check to see that jumper "A" on Card #5 (included with the Conversion Kit) is also in the STEREO position.

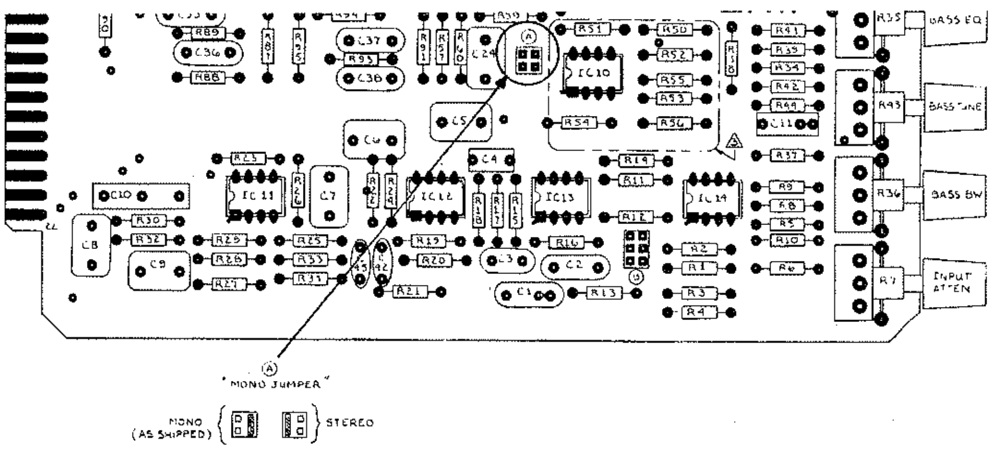


Fig. G-1: Stereo Conversion Jumper "A" -- Cards #4 And #5

3) You now have a number of decisions to make regarding stereo initialization options. For example, the OPTIMOD-AM output can be strapped in either L/R or L+R/L-R modes. Turn to the **Initialization Options** section of **Part 3: Installation,** and follow the procedure described in this section, starting with **Option 2.** When you are done, return to (4) immediately below.

4) If you are operating with the Kahn/Hazeltine stereo system, you may wish to use the Accessory Port. This port, which is discussed more fully in the **AM Stereo** section of **Part 2: Various Application Notes,** permits breaking the L+R signal path between the exciter AM output and the transmitter audio input. The exciter's AM output is returned to OPTIMOD-AM through the Accessory Port. It

is then processed by the OPTIMOD-AM safety clippers and Transmitter Equalizer before being returned to the transmitter. This compensates for the fact the Kahn/Hazeltine exciter may insert phase shift networks in the L+R signal path which will upset peak levels. By placing the OPTIMOD-AM safety clippers after such phase shift networks in the exciter, peak envelope modulation is properly controlled. [The phase-modulation (PM) component is controlled by clippers within the Kahn/Hazeltine exciter.]

Appendix I: Application Of The Accessory Port provides instructions for using this Port. For convenience, you may wish to perform this work at the same time that you are performing the current Stereo Conversion Procedure.

5) If you have ordered the Optional Stereo Enhancement Card (Card #1-S) as part of your stereo conversion, this card must be installed before the **Alignment Procedure** below is performed. Instructions for doing this are found in **Appendix H: Installation Of The Optional Filter Card.**

   (Card #1-S is required for the Motorola system and may be useful for the Kahn system. See **AM STEREO** in **Part 2** of this manual.)

   Refer to **Appendix H: Installation Of The Optional Filter Card.**

6) Seven IC's have been provided: (2ea.) NE5532, (1ea.) NE5534, and (4ea.) TL072. Referring to the Card #2/#3 Assembly Drawing in **Appendix J,** install the NE5532's in the IC14 sockets on Cards #2 and #3. Install the four TL072's in the IC3 and IC8 sockets of Cards #2 and #3. Install an NE5534 in the IC19 socket of Card #2 only.

   CAUTION!

   Each chip must be oriented such that the end with the notch or dot is at the end of the socket marked with a square or small flag on the circuit board foil. If any chip is installed reversed, it will be instantly destroyed on powerup!

7) If you are not going to perform the **Alignment** below, install all cards in their slots. Otherwise, proceed to the **Alignment** instructions.

ALIGNMENT

The 9100A/2 system provides two alternate means of optimizing separation. The first (simplified) means is the SEPARATION trimmer on Card #10. This adjusts the gain of the entire difference channel in a frequency-independent way. The simplified technique is usually adequate for typical installations and will usually meet FCC specifications.

The second means is adjusting the BALANCE trimmer on each difference-channel VCA in the Six-Band Limiter. This provides a frequency-dependent means of achieving the closest possible match between the sum and difference (L+R and L-R) channels, and therefore a means of achieving the best separation obtainable from the system. (These adjustments can also be useful in improving the performance of an AM Stereo Exciter/Transmitter combination, in which case separation is measured and optimized through the entire processor/transmitter chain.) However, this complete procedure requires an audio sweep generator with log sweep and is therefore unsuited for stations without this piece of equipment.

We therefore provide two procedures: a simplified one for use with the SEPARATION trimmer and a complete, optimum one for use with the six VCA BALANCE trimmers.

a) **Preparation For Either Procedure**

1) If the optional Stereo Enhancement Card (#1-S) is installed, temporarily strap Jumper "E" on this card for "12KHZ ALL TIMES". The STEREO ENHANCE control (R85) on Card #1-S must be fully counterclockwise.

2) If at least one of the sets of OPTIMOD-AM outputs is not already strapped for L/R operation, remove Card #8 from its slot. (Card #9 should not yet be installed.) Temporarily restrap the TX1 outputs of Cards #8 and #9 for L/R operation by following the instructions in the Installation **Options** section of **Part 3: Installation,** or by referring to the schematic diagrams for the #8 and #9 Cards in **Appendix J.**

3) Install the new #5, #9, and #10 Cards and make sure that all other cards are installed in their slots.

   (Slots are numbered backwards from #10 on the far right. Card connectors are keyed, but some card pairs have the same keying.)

4) Set the operating controls as follows, noting the positions of the controls for restoration later:

   (controls not listed: DON'T CARE)

L&R INPUT ATTEN	7
EQ	OUT
L DENS	7
R DENS	0
MODE	PROOF
TX EQ	OUT
TX1 OUTPUT ATTEN (BOTH)	FULLY CLOCKWISE

b) **Simplified Separation Optimization**

1) Required Equipment

   -- Audio frequency sinewave generator
   -- AC voltmeter
   -- Card Extender (supplied with your 9100A)

2) Apply the audio generator to the OPTIMOD-AM L Input. Set the oscillator's frequency to 1.6kHz and advance its output level until the OPTIMOD-AM VU meter reads -10VU in the L+R 12KHZ FILTER position of the METER FUNCTION switch.

3) Observe the TX1 L Output with the AC VTVM and note the level. Use this level as the "0dB" reference when estimating separation.

   Observe the TX1 R Output with the AC VTVM. Extend Card #10, and adjust R58 (SEPARATION) on this card to minimize the level at this test frequency. Spot check at 50, 100, 200, 400, 1000, 2500, and 5000Hz to make sure that the output is better than 25 dB below the level observed at the TX1 L Output.

   (**Note:** If Card #1-S is installed and its Jumpers "A" and "B" are strapped for "200HZ FILTER IN", there will be almost no separation below 200Hz. This is normal.)

G

4) Return Card #10 to its slot.

5) Go to **(d) (Wrapup)** below.

c) Comprehensive Separation Optimization (Alternate Procedure)

1) Required Equipment:
   -- Audio Sweep Generator with 20-20kHz log sweep capability
   -- Oscilloscope with X/Y capability
   -- Card Extender (supplied with your 9100A)

2) Connect the sinewave output of the sweep generator to the OPTIMOD-AM L Input. Connect the TX1 R Output to the Y (vertical) input of the scope. Connect the sweep ramp output of the generator to the X (horizontal) input of the scope.

3) Adjust the generator for an approximately 20-20kHz log sweep, and adjust its output level to produce a reading of -10VU on the OPTIMOD-AM VU meter with the METER FUNCTION switch in the L+R 12KHZ FILTER position. Adjust the sensitivity controls on the scope until the swept response is easily seen.

4) Adjust all six BALANCE trimmers on Cards #2 and #3 (R57, R86, and R114 on each card) to achieve the lowest possible level as displayed on the scope. (These trimmers are accessible from the front without extending the cards. However, they are located some distance back on the cards, so a long insulated screwdriver or plastic alignment tool should be used to avoid shorts.)

   While adjusting the controls for maximum separation, you will notice some interaction between them. Iterate between the controls until approximately "equal-ripple" separation is obtained: i.e., no one peak of minimum separation dominates the sweep.

5) If you wish, you may perform this adjustment through the entire transmitter, observing the R Output of your stereo monitor instead of the R Output of OPTIMOD-AM. This way, you can optimize separation through the entire system by "predistorting" the processor adjustments to equalize separation losses later in the system.

d) Wrapup

1) If you had temporarily restrapped Optional Card #1-S in step (a.1) above, restore it to the desired operating mode. Restore the STEREO ENHANCE control on Card #1-S to its desired setting.

2) Install the new subpanel. The old one may be discarded. To avoid RFI problems, be sure that all cards are correctly seated in their slots and that all screws and Dzus fasteners are secure.

3) Restore the Operating Controls to their original positions, duplicating the original settings of Card #4 on the newly-installed Card #5. Turn the TX1 OUTPUT ATTEN controls fully CCW to avoid unexpected overmodulation when you first activate the transmitter following this conversion procedure.

4) Refer to **Part 4** for further instructions on initial setup in stereo.

Appendix H:
Installation and Operation of the Optional Filter Card

GENERAL

Card #1-S is an optional card which plugs into slot #1 of the OPTIMOD-AM mainframe. It exists primarily to provide special processing for the various AM stereo systems. It offers three functions which can be used in any combination as needed:

1) Single-Channel Modulation Limiter And Stereo Enhancer
2) 5kHz Lowpass Filter (Stereo)
3) 200Hz L-R Highpass Filter (and phase-matching L+R allpass filter).

The card is <u>always</u> required for the Motorola system, and is <u>optional</u> (but possibly advantageous) for the Kahn system.

Application of Card #1-S is discussed in **AM STEREO** in **Part 2** of this manual.

INSTALLATION OF THE CARD

THE ENTIRE INSTALLATION PROCEDURE CAN BE PERFORMED WITHOUT REMOVING THE OPTIMOD-AM CHASSIS FROM THE RACK.

BE SURE TO SWITCH OFF AC POWER BEFORE REMOVING OR INSTALLING CARDS.

Mainframe Strapping

Referring to **Appendix C: User Access** in this manual, remove Cards #7 and #10 from their slots. Referring to Fig. H-1 below, strap jumper "A" on each card to the LOWPASS FILTER IN position. (This activates signal paths to the #1 Card connector.) Then reinsert the cards in their slots.

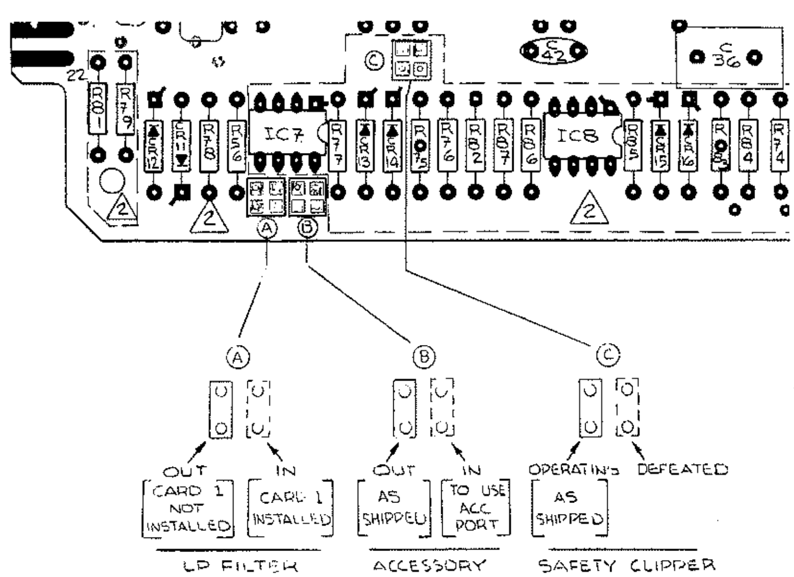


Fig. H-1: Cards #7 And #10 Strapping

ADJUSTMENT AND JUMPER STRAPPING OF THE #1-S CARD

Refer to the **Assembly Drawing** for Card #1-S in **Appendix J** of this Manual.

(The **AM STEREO** section in **Part 2** of this manual provides information on choosing the correct jumper configuration for your application.)

1) **Single-Channel Limiter and/or Stereo Enhancer:** Refer to the **Assembly Drawing** and move jumpers "C" and "D" (Compatibility Control/Stereo Enhancer) to the IN position (as shipped).

   In Kahn installations, if these jumpers are IN to activate the stereo enhancer feature, then one side of CR7 and CR11 should be desoldered and lifted from the card. If this is not done, distortion may be higher than necessary on certain types of program material containing high amounts of separation. (See **Appendix I** in this manual.)

   The STEREO ENHANCE control (R85) is a stand-up trimmer at the front of Card #1-S. When R85 is fully counterclockwise (CCW), the normal stereo separation built into the program material is provided. As R85 is rotated progressively CW, separation becomes more and more exaggerated. R85 should be adjusted by ear for best effect. (For greatest fidelity to the original program material, it should be used sparingly or not at all.)

   R85 is accessible for adjustment only when the OPTIMOD-AM subpanel has been removed. If RFI makes this impractical, a hole may be drilled through the subpanel, or adjustments may be made in steps by taking the station off the air when adjustment is made. Since the adjustment is not critical, this should not be too arduous a task!

2) **5kHz Lowpass Filter:** To choose the desired mode, move jumper "E" according to the **Assembly Drawing.** If no filtering is required, jumper "E" must be placed in the "12kHz ALL TIMES" position (as shipped).

3) **200Hz L-R Highpass Filter:** If you are using L-R telemetry or LF SCA, place jumpers "A" and "B" in the IN position, referring to the **Assembly Drawing.** Otherwise, leave jumpers "A" and "B" in the OUT position (as shipped).

   You may now insert Card #1-S in its slot.

4) **Mainframe:** Gains through Card #1-S are set by means of precision 1% resistors. Although installation of the card will never cause separation to deteriorate below 25dB, the purist engineer may wish to perform the simplified separation optimization procedure (b) described in **Appendix G: Stereo Conversion** in this manual. This procedure should be performed after all jumpers on Card #1-S have been set to their final operating positions, but with the STEREO ENHANCE control fully CCW. Note that no separation will be produced below 200Hz if the 200Hz L-R Highpass Filter is IN.

5) This concludes the Installation Instructions. Be sure to replace the subpanel and fasten all connectors tightly to avoid RFI.

Appendix I:
Application of the Accessory Port

GENERAL (**NOTE:** This **Appendix** has been extensively revised for this Third Edition of the Operating Manual.)

This Appendix is primarily of interest to those installing Kahn exciters. The first few paragraphs provide general information on the purpose of the Accessory Port.

Comments herein were developed in early 1985 using the best information available at the time.

CAUTION!

ORBAN ASSOCIATES INC. SPECIFICALLY DISAVOWS ANY RESPONSIBILITY FOR POSSIBLE VIOLATION OF FCC RULES INCURRED IN THE COURSE OF THESE PROCEDURES. IT IS THE RESPONSIBILITY OF THE LICENSEE TO OBTAIN AUTHORIZATION FOR ANY EXCITER MODIFICATIONS FROM THE EXCITER MANUFACTURER TO ASSURE THAT FCC TYPE ACCEPTANCE OF THE EXCITER IS NOT COMPROMISED.

The Accessory Port provides a means of inserting part of an AM stereo exciter (containing filters which may disturb peak levels) between the OPTIMOD-AM output filter and the OPTIMOD-AM safety clipper. Thus spurious modulation peaks introduced by the exciter are correctly controlled and full loudness is obtained.

The Port is supplied with every OPTIMOD-AM. It consists of an Amphenol or Cinch 57-40140 14-pin ribbon connector. (The mating plug is 57-30140, supplied.) See Fig. I-1 for wiring format.

To the best of our knowledge, only the Kahn exciters (types STR-77 and STR-84) require use of the Accessory Port for best system performance. THERE ARE MAJOR DIFFERENCES BETWEEN APPLICATION OF THE ACCESSORY PORT WITH THE STR-77 AND THE STR-84 EXCITERS. EACH EXCITER IS DISCUSSED SEPARATELY, WITH THE STR-77 FIRST. Please refer to **AM STEREO** in **Various Application Notes (Part 2)** of this manual for an overview of "The Kahn System And The Accessory Port".

INTERFACING THE KAHN TYPE STR-77 EXCITER

The Kahn STR-77 exciter contains built-in clippers for both the AM (envelope modulation: L+R) and PM (phase modulation) component. It is not practical to break the L-R signal path within the Kahn STR-77 exciter, so peak modulation control of the PM component must be provided by the STR-77 exciter's built-in L-R clipper.

However, we recommend that the L+R clippers in the Kahn STR-77 exciter not be used. Instead, the "L+R OUT" on the STR-77 exciter (ordinarily connected to the transmitter audio input) is routed back to OPTIMOD-AM through the Accessory Port to permit peak control and L+R transmitter equalization to be performed by OPTIMOD-AM circuitry.

IMPORTANT!

Do not attempt to optimize separation or other stereo parameters until the STR-77 exciter has been fully interfaced with OPTIMOD-AM. Follow the instructions below carefully; they indicate at which point STR-77 exciter adjustments should be made to optimize stereo performance.

Connections

1) **STR-77 Exciter Input Connection:** Connect the OPTIMOD-AM TX1 L OUTPUT to the left input of the STR-77 exciter, and connect the OPTIMOD-AM TX1 R OUTPUT to the right input of the STR-77 exciter.

2) **STR-77 Exciter Output Connection:** Connect the STR-77 exciter "L+R OUT" to pins 7 and 6 (ground) of the Accessory Port. Since the Accessory Port provides a bridging input, terminate the STR-77 exciter "L+R OUT" with a 620ohm ±5% 1/4 watt resistor.

3) **Connection To TX AM Input:** Connect the OPTIMOD-AM TX2 L+R output to the audio input of the transmitter. Choose the polarity which yields non-reversed stereo channels when the system is observed on the Kahn monitor.

4) **Redundant STR-77 Exciters:** If you have a redundant system with two transmitters (each driven by its own stereo STR-77 exciter), drive both STR-77 exciters inputs in parallel from the TX1 output amplifiers. Return STR-77 exciter #1's "L+R OUT" to pins 7 and 6 of the Accessory Port (as described above), and return STR-77 exciter #2's "L+R OUT" to pins 1 and 2 (ground) of the Accessory Port. The remaining OPTIMOD-AM safety clipper, supersonic lowpass filter, and program amplifier (ordinarily used for L-R) instead process L+R from the second STR-77 exciter and drive the second transmitter.

   The OPTIMOD-AM TX Equalizer can be used to optimize the performance of the transmitter(s) for minimum tilt and overshoot. The L+R TX EQ controls are fully equipped to handle older transmitters (particularly plate-modulated rigs which usually suffer from substantial LF tilt). However, the L-R TX EQ provides no LF tilt correction. Therefore, if you have two transmitters in a redundant STR-77 exciter setup -- a modern type with minimum tilt, and an older type -- use the STR-77 exciter connected to the L-R audio chain (pins 1 and 2 of the Accessory Port) for the modern transmitter, and use the STR-77 exciter connected to the L+R audio chain (pins 7 and 6) for the older transmitter. (In this setup, the OPTIMOD-AM L-R TX Equalizer functions as an L+R TX Equalizer for the modern transmitter.)

5) **STR-77 Exciter Clipper Defeat:** Defeat the Kahn L+R clippers by turning the Kahn positive and negative limiter threshold controls (on Card #7 of the Kahn STR-77 exciter) fully clockwise.

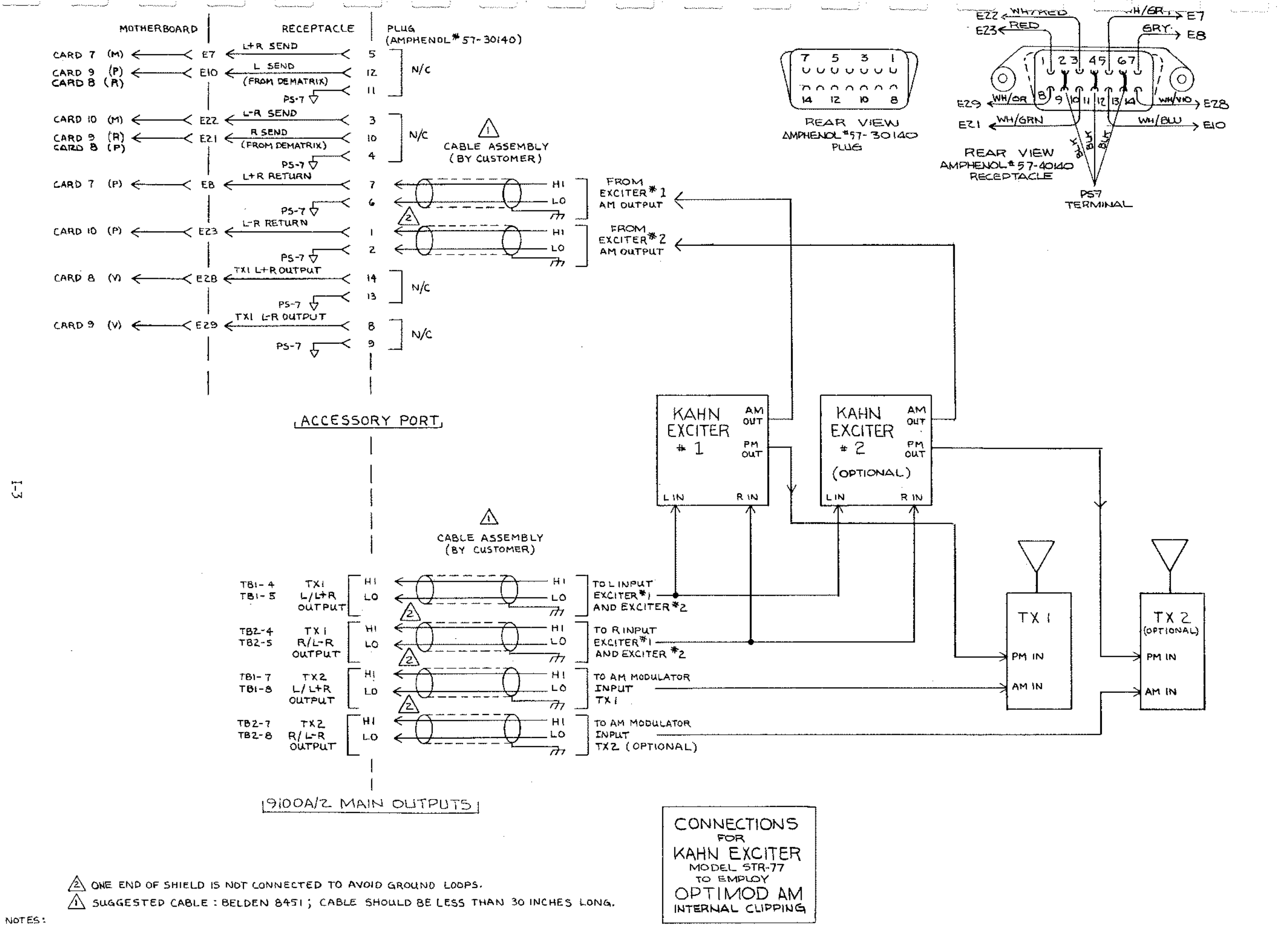


Fig. I-1: Accessory Port Application Example; Wiring To And From STR-77 Exciter

Card Strapping And STR-77 Exciter Alignment

This procedure refers specifically to the Kahn system.
You will require a sinewave oscillator and an AM stereo monitor or calibrated receiver for alignment.

CARD STRAPPING AND EXCITER ALIGNMENT

1) Adjust the OPTIMOD-AM operating controls as follows:

(controls not listed: DON'T CARE)

L&R INPUT ATTEN	7
EQ	OUT
L DENS	7
R DENS	0
MODE	PROOF
TX EQ	OUT

2) When you have finished adjusting the controls, gain access to the circuit cards, following the instructions in **Appendix C: User Access.** Be sure to turn off AC power.

3) **Strapping The OPTIMOD-AM Jumpers:** Jumper strapping for this application is somewhat unconventional because the TX1 program amplifiers are used to drive the STR-77 exciter, while the TX2 program amplifiers are used to drive the transmitter(s).

The STR-77 exciter requires L/R sends. This is achieved by diverting the inputs of the OPTIMOD-AM dematrix circuit away from their usual driving source (the TX equalizer), and instead connecting them ahead of the OPTIMOD-AM safety clippers. The matrix L and R outputs are then strapped to drive the TX1 output amplifiers, which in turn drive the STR-77 exciter inputs.

On Card #9, place jumpers "A" and "B" in the "Diverted" position. Place jumper "C" in the "R" position, and place jumper "D" in the "L-R" position.

On Card #8, place jumper "C" in the "L" position, and place jumper "D" in the "L+R" position. (See Fig. I-2 below.)

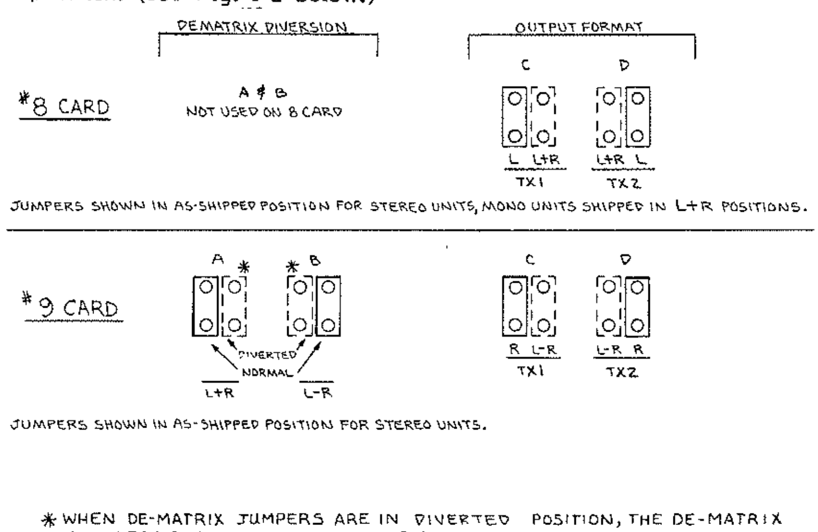


Fig. I-2: Card #8/#9 Jumpers

4) Remove Cards #7 and #10 and make sure that jumper "B" is strapped for ACCESSORY PORT OUT, as in Fig. I-3.

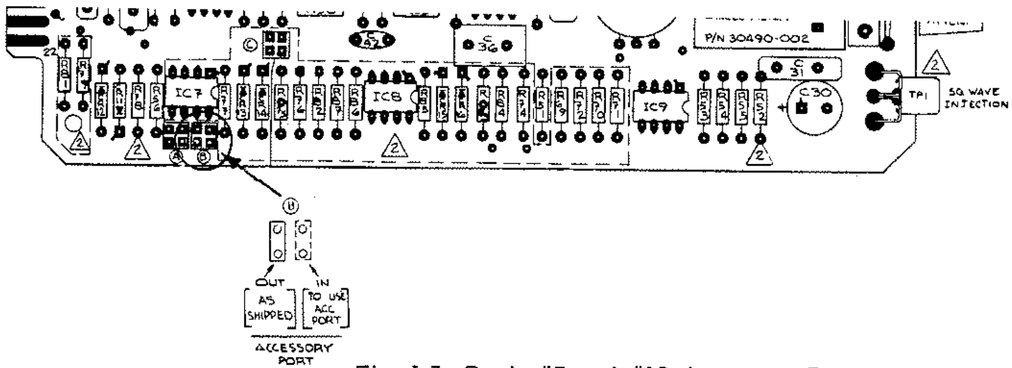


Fig. I-3: Cards #7 and #10 Accessory Port Jumper

Replace Cards #7 and #10. Turn AC power ON.

5) Apply a 1kHz sinewave to the OPTIMOD-AM L Input and adjust the oscillator level until the VU meter reads 0VU with the METER FUNCTION switch in the L+R 12KHZ FILTER postion. (This level is 5dB below 100% peak modulation.) Then read the VU meter in the L-R 12KHZ FILTER position and verify that it is 0VU $\pm$1dB.

6) Move the oscillator output to the OPTIMOD-AM R Input. Advance the R DENSITY control until the VU meter reads 0VU in the L+R 12KHZ FILTER position of the METER FUNCTION switch. Then read the L-R 12KHZ FILTER position and verify that it is 0VU $\pm$1VU. Do not change the settings of the OPTIMOD-AM INPUT ATTEN or DENSITY controls until the procedure is completed.

   Remove Cards #7 and #10, and strap jumper "B" on each card for ACCESSORY PORT IN, following Fig. I-3. Replace the cards in their slots.

   Connect the STR-77 exciter to the Accessory Port. If the OPTIMOD-AM TX1 L and TX1 R outputs were not already connected to the STR-77 exciter L and R inputs, connect them now.

7) **STR-77 Exciter Drive Level Adjust:** Advance the STR-77 exciter L and R Gain controls fully clockwise. Adjust the OPTIMOD-AM TX1 R OUTPUT ATTEN until the STR-77 exciter "R" meter reads -5VU. Then move the oscillator output back to the OPTIMOD-AM L input, and adjust the OPTIMOD-AM TX1 L OUTPUT ATTEN until the STR-77 exciter "L" meter reads -5VU.

8) **Unity Gain Adjust:** Advance the STR-77 exciter L+R MODULATION CONTROL (on Card #7) until the OPTIMOD-AM VU meter reads 0VU in the L+R 12KHZ FILTER position.

   If you are using two STR-77 exciters in a redundant setup, advance the second STR-77 exciter's L+R MODULATION CONTROL until the OPTIMOD-AM VU meter reads 0VU in the L-R 12KHZ FILTER position.

9) **TX EQ Adjust:** The OPTIMOD-AM TX Equalizer may be used to correct the amplitude modulator (L+R) section of the transmitter(s). Correction of tilt will also tend to improve stereo separation because the bass response of the transmitter modulator is extended and phase errors are reduced.

   Follow the instructions in **Part 4: Setup Procedure** (starting at p. 4-1), bearing in mind that the instructions regarding stereo should be ignored because of the unconventional interface with the STR-77 exciter. Remember that both the L+R and L-R TX EQ control groups serve as <u>L+R</u> equalizers for their respective transmitters in a dual transmitter installation.

When you have finished adjusting the TX EQ, return to step (10) below.

10) **Modulation Adjustments:** Restore the OPTIMOD-AM Operating Controls to their normal settings and place the MODE switch in OPERATE. Using program material, adjust the OPTIMOD-AM TX2 OUTPUT ATTEN for the appropriate transmitter to achieve the desired envelope modulation level (usually 99% negative).

    Set the OPTIMOD-AM POS PEAK THRESH control at "100%", and verify that positive peaks read 99% $\pm$2%. If substantial asymmetry is observed, this indicates a problem with transmitter linearity which should be investigated and corrected before proceeding further. [While the most common problem is positive peak compression (usually indicating flat modulator or RF final amplifier tubes), PDM-type transmitters can exhibit excessive positive peak modulation which is usually caused by a problem in the low-level sections of the transmitter.]

11) Now that the L+R drive and L+R TX EQ adjustments have been made, the STR-77 exciter can be aligned according to instructions provided by Kahn to optimize separation and other AM stereo parameters. You may restore OPTIMOD-AM to PROOF mode to provide tone inputs to the STR-77 exciter for such measurements. However, do not change the settings of the STR-77 exciter input attenuators or L+R output attenuator, and do not change the settings of the OPTIMOD-AM output attenuators or TX EQ setup controls. Any such changes will result in excessive distortion or insufficient loudness due to overdrive or underdrive of the OPTIMOD-AM or Kahn clippers.

This concludes the instructions for interface of OPTIMOD-AM with the STR-77 exciter.

INTERFACING THE KAHN TYPE STR-84 EXCITER

By comparison to the STR-77 exciter, the STR-84 exciter is much improved, and contains a loop-through facility which allows you to place the phase difference networks before most of the OPTIMOD-AM processing. If this is done, the L+R and L-R clippers on OPTIMOD-AM's optional Card #1-S (if installed) can work properly to control modulation levels. If this is not done, distortion and/or loudness penalties will be paid as in the case of the first-generation (STR-77) exciter.

The following description of a modification to OPTIMOD-AM to accomodate the Kahn STR-84 exciter is conjectural, and is based on a preliminary version of the STR-84 Instruction Manual. Because type acceptance of the STR-84 has been recent as this is written, we have not had "hands-on" experience with the new STR-84 exciter. Therefore, please be on guard!

The Kahn STR-84 exciter (to which we will be referring from here on) breaks its signal flow after the phase-difference networks, and provides L+R and L-R inputs and outputs to incorporate audio processing. The best location for the phase difference networks is between the OPTIMOD-AM Program Equalizer and Six-Band Limiter. Accessing this point requires some rewiring of the OPTIMOD-AM Accessory Port and backplane.

The Big Picture: What you will accomplish by the maneuver described below is this: The audio is applied to the first part of OPTIMOD-AM (consisting of the Broadband AGC and Program Equalizer) in conventional L/R form. After processing by these elements, the signal (still in L/R form) is passed into the STR-84 exciter. The OPTIMOD-AM TX1 program amplifiers are rewired so that they can drive the input of the STR-84 exciter.

The STR-84 exciter derives L+R and L-R and also passes the signal through the phase shift networks necessary to achieve Independent Sideband operation. This part of the STR-84 exciter is essentially linear, and the only constraints on operating level through this section are its clipping point and noise floor.

The signal emerges from the Kahn STR-84 exciter in sum-and-difference (L+R/L-R) form. This signal is applied to the input of the OPTIMOD-AM Six-Band Limiter. From here until the last stage of OPTIMOD-AM, the signal is processed in L+R/L-R form. Since all phase shift networks precede the OPTIMOD-AM clippers, these clippers will control peak levels properly.

The modulator portion of the STR-84 exciter is fed from the OPTIMOD-AM TX2 program amplifiers. This way, modulation levels can be set with the OPTIMOD-AM TX2 L+R and TX2 L-R OUTPUT ATTENuators. (In practice, envelope modulation is first set with the L+R ATTEN. Then the L-R ATTEN is adjusted to maximize separation.)

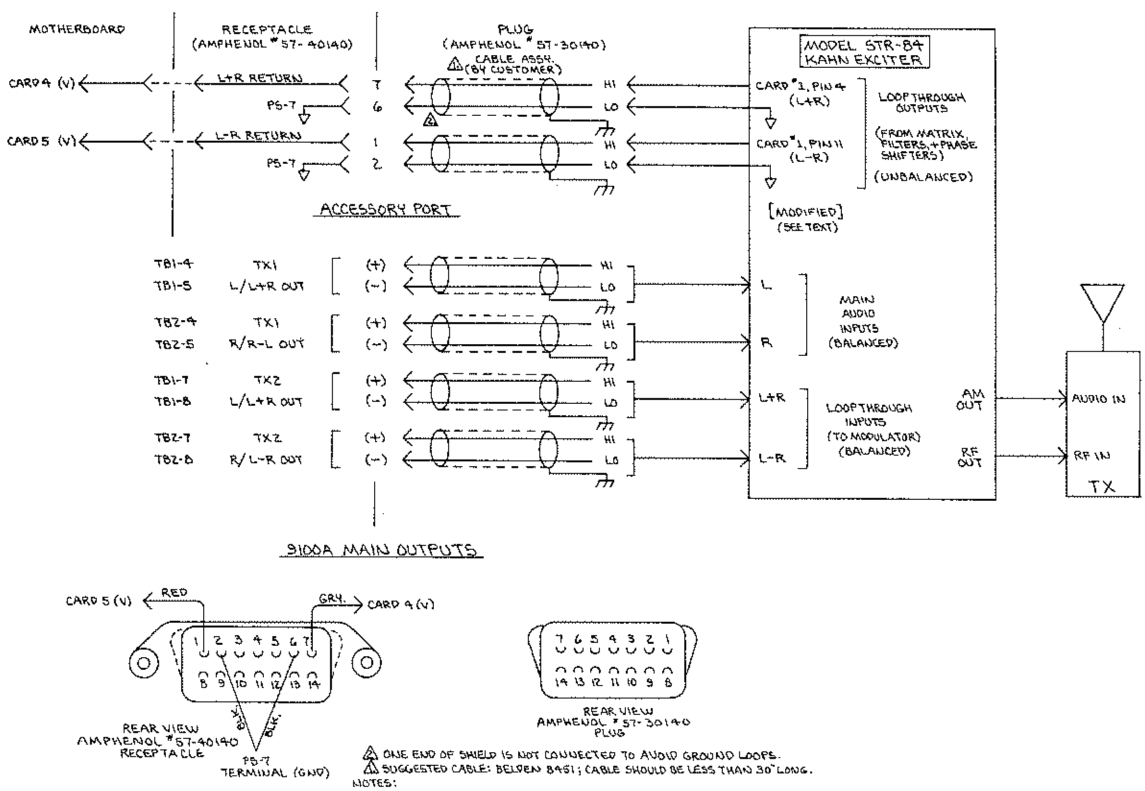


Fig. I-4: Interconnection Of The Second-Generation Kahn STR-84 exciter With OPTIMOD-AM And The Transmitter

Procedure:

1) Gain access to the area behind the rear panel, following the directions in paragraph **2.b** in **Appendix** C of your **Optimod Operating Manual.** (Careful attention to these instructions can save you substantial time, since you will find that it is unnecessary to remove the top and bottom covers and most of the screws.)

2) (L Send) Disconnect the white/blue wire from terminal 12 on the Accessory Port and tack-solder it to pin S of the Card #4 connector. (Extend the wire if necessary. The legend for the pin numbers is etched in the motherboard at the leftmost card position. Note particularly that certain letters are omitted among the alphabetically-labelled pins.)

3) (R Send) Disconnect the white/green wire from terminal 10 on the Accessory Port. Tack-solder it to pin S of the Card #5 connector.

4) (L+R Return) Disconnect the grey wire from terminal E8 on the motherboard. Tack-solder it to pin V of the Card #4 connector.

5) (L-R Return) Disconnect the red wire from terminal E23 on the motherboard. Tack-solder it to pin V of the Card #5 connector.

6) Check your work carefully. Verify that all wires go to the correct pins, and that no short-circuits have been introduced between pins. When you are satisfied that all is well, replace the rear panel (see **Appendix C** in this manual.)

7) **Circuit Card Jumper Positioning And Modifications:** Once again, following **Appendix C,** gain access to the circuit cards and remove Card #5 from its slot. Referring to the Card #5 Assembly Drawing in **Appendix J** in this manual, remove IC10 from its socket. This defeats the OPTIMOD-AM matrix and permits the Kahn STR-84 exciter's internal matrix to be used in its place. [If this IC is not removed, there will be two opamps (one from the Kahn STR-84 exciter and one from OPTIMOD-AM) attempting to drive the L+R and L-R Return points, and severe distortion will occur.]

   Place jumper "A" in the STEREO position (if it is not already there). Then remove Card #4 from its slot, and place its jumper "A" identically.

   Remove Cards #8 and #9 from their slots. Referring to the Card #8 and #9 Assembly Drawings in **Appendix J** of this manual, strap the TX1 outputs for L/R operation and the TX2 outputs for L+R/L-R operation (using jumper "C" on both cards). Then remove IC3 on Card #9 from its socket. [This permits IC4 on Cards #4 and #5 to drive the lines ordinarily driven by the L and R outputs of the dematrix (IC3) on Card #9. The TX1 program amplifiers are now being driven by the outputs of IC4 on Cards #4 and #5 respectively.] The matrix jumpers (on Card #9) should be in the NORMAL position, as determined by jumpers "A" and "B".

   (In this configuration, the TX1 output amplifiers drive the STR-84 exciter's audio inputs, and the TX2 output amplifiers drive the STR-84 exciter's L+R and L-R returns.)

   IF THE OPTIONAL CARD #1-S IS INSTALLED, remove it from its slot. Strap the 200Hz Filter OUT, the Single-Channel Limiter/Stereo Enhance Circuit IN, and the 5kHz Filters as desired. See **Appendix** H of this manual.

   Return Cards #1-S, #4, #5, #8, and #9 to their slots.

NOTE: It would be wise to write notes at the fronts of both the Optimod and Kahn Manuals advising future engineers of the changes. It would also be prudent to attach a paper label to the rear of OPTIMOD-AM saying "Nodes for the Accessory Port re-routed per Orban instructions for the second-generation Kahn STR-84 exciter. See **Appendix** I of the **9100A Operating Manual.**"

8) **Wiring To The STR-84 Exciter:** Connections to the STR-84 exciter are made from both the OPTIMOD-AM Accessory Port and OPTIMOD-AM's TX1 and TX2 output terminals, the latter being located on OPTIMOD-AM's rear-panel barrier strip. (The OPTIMOD-AM Accessory Port accepts an Amphenol #57-30140 plug.) Refer to Fig. I-5 below, and wire the plug and rear-panel barrier strip to the STR-84 exciter as follows:

    1) L SEND (to STR-84 exciter L audio input):
    (+)=TX1 L/L+R "+ OUT"; (-)=TX1 L/L+R "- OUT"
    2) R SEND (to STR-84 exciter R audio input):
    (+)=TX1 R/L-R "+ OUT"; (-)=TX1 R/L-R "- OUT"
    3) L+R RETURN (from STR-84 exciter's L+R loopthru output):
    HOT=PIN 7 of Accessory Port; GND=PIN 6 of Accessory Port
    4) L-R RETURN (from STR-84 exciter's L-R loopthru output):
    HOT=PIN 1 of Accessory Port; GND=PIN 2 of Accessory Port
    5) L+R SEND (to STR-84 exciter's L+R loopthru input):
    (+)=TX2 L/L+R "+ OUT"; (-)=TX2 L/L+R "- OUT"
    6) L-R SEND (to STR-84 exciter's L-R loopthru input):
    (+)=TX2 R/L-R "+ OUT"; (-)=TX2 R/L-R "- OUT"

NOTE: The connections to the Accessory Port are unbalanced, and should be run only short distances through foil-shielded cable. This ordinarily implies mounting OPTIMOD-AM immediately above or below the STR-84 exciter.

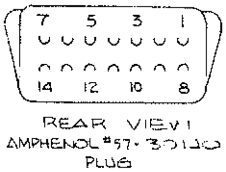


Fig. I-5: Rear View, Amphenol #57-30140 Plug

Modifications To STR-84 "External Processing Interface" Card

The levels and impedances provided by the STR-84's External Processing Interface card (Card #1) are not ideally matched to the levels and impedances required by OPTIMOD-AM. The following modifications of the STR-84's Card #1 are therefore recommended to assure best headroom and signal-to-noise ratio from the combination of OPTIMOD-AM and the STR-84.

1) Gain access to the STR-84's Card #1 and remove it.

2) The nominal gain of the L+R and L-R drive amplifiers is currently +20.8dB. Because the nominal level required by OPTIMOD-AM at this point is 109mv rms, it is advisable to lower the gain of these amplifiers to 0dB to avoid excessive noise. To do this, unsolder and lift one side of R2 and R21 (both 10K).

I

3) The OPTIMOD-AM circuitry which is driven by these amplifiers requires a 0 ohm driving impedance, unbalanced. As shipped, the STR-84 provides a driving impedance of 600 ohms, balanced-to-ground. To achieve the proper interface, OPTIMOD-AM must be driven between pin 4 of the STR-84's Card #1 and circuit ground (L+R drive), and pin 11 of the STR-84's Card #1 and ground (L-R drive). In addition, R7 and R26 on the STR-84's Card #1 (both 300 ohms) must be shorted-out or replaced by hard-wire jumpers to provide 0 ohms drive.

4) This concludes the modifications. Replace Card #1 in its slot in the STR-84.

Adjustment

1) Adjust the OPTIMOD-AM operating controls as follows:

(controls not listed: DON'T CARE)

L&R INPUT ATTEN	5
EQ	OUT
L DENS	4
R DENS	4
MODE	PROOF
TX EQ	OUT

2) Connect an audio oscillator to the L OPTIMOD-AM Input. Set its frequency to 400Hz and adjust its output level to produce a reading of "0 VU" on OPTIMOD-AM's VU meter in the L AGC position.

3) Adjust OPTIMOD-AM's TX1 L OUTPUT ATTEN to produce 109mv rms across the (+) and (-) TX1 L OUTPUT terminals on OPTIMOD-AM's rear panel. Then adjust the STR-84's L INPUT ATTENUATOR to produce 109mv rms at its "L+R TO PROCESSOR" output. (This output should be taken between pin 4 of the STR-84's Card #1 and circuit ground of the STR-84.)

5) Repeat steps (2) through (4) for the RIGHT CHANNEL. (Replace all references to "L" or "LEFT" by "R" or "RIGHT".)

6) **Modulation Adjust:** Turn both OPTIMOD-AM TX2 OUTPUT ATTEN controls all the way down (fully CCW). Readjust OPTIMOD-AM for normal operation, and drive it with program material. Advance the OPTIMOD-AM TX2 L+R OUTPUT ATTEN to secure normal envelope modulation (-99% negative peaks and positive peaks as desired).

7) **Separation Adjust:** Return OPTIMOD-AM to PROOF mode. Temporarily turn its R DENSITY control to "0". Apply 1kHz to its LEFT INPUT and adjust the oscillator output level to produce 25% envelope modulation.

Observe the R OUTPUT of the Kahn monitor receiver, and advance OPTIMOD-AM's TX2 L-R OUTPUT ATTENUATOR to null the signal appearing at the R OUTPUT, thus maximizing separation. (This operation should result in best gain balance between the L+R and L-R signal paths in OPTIMOD-AM. It will only be successful if the STR-84 exciter and monitor receiver are calibrated and operating correctly.)

7) This concludes interconnection and calibration of OPTIMOD-AM to the Kahn STR-84 exciter. Enter OPERATE mode, and readjust OPTIMOD-AM for normal operation.

This concludes **Appendix I (Application Of The Accessory Port.)**

Appendix J:
Schematics, Assembly Drawings and Parts List

The documents in this Appendix reflect the actual construction of your unit as accurately as possible. If changes are made, they will be found in an Addendum inserted in the front of this Manual. If there is a disagreement between these drawings and your actual unit, it more likely reflects an error in documentation than an error in the construction of your unit.

If you intend to replace parts, please consult the section in **Appendix F** on **Selecting And Ordering Replacement Parts.**

Schematic drawings for the major cards face the corresponding Parts Locator Drawing.

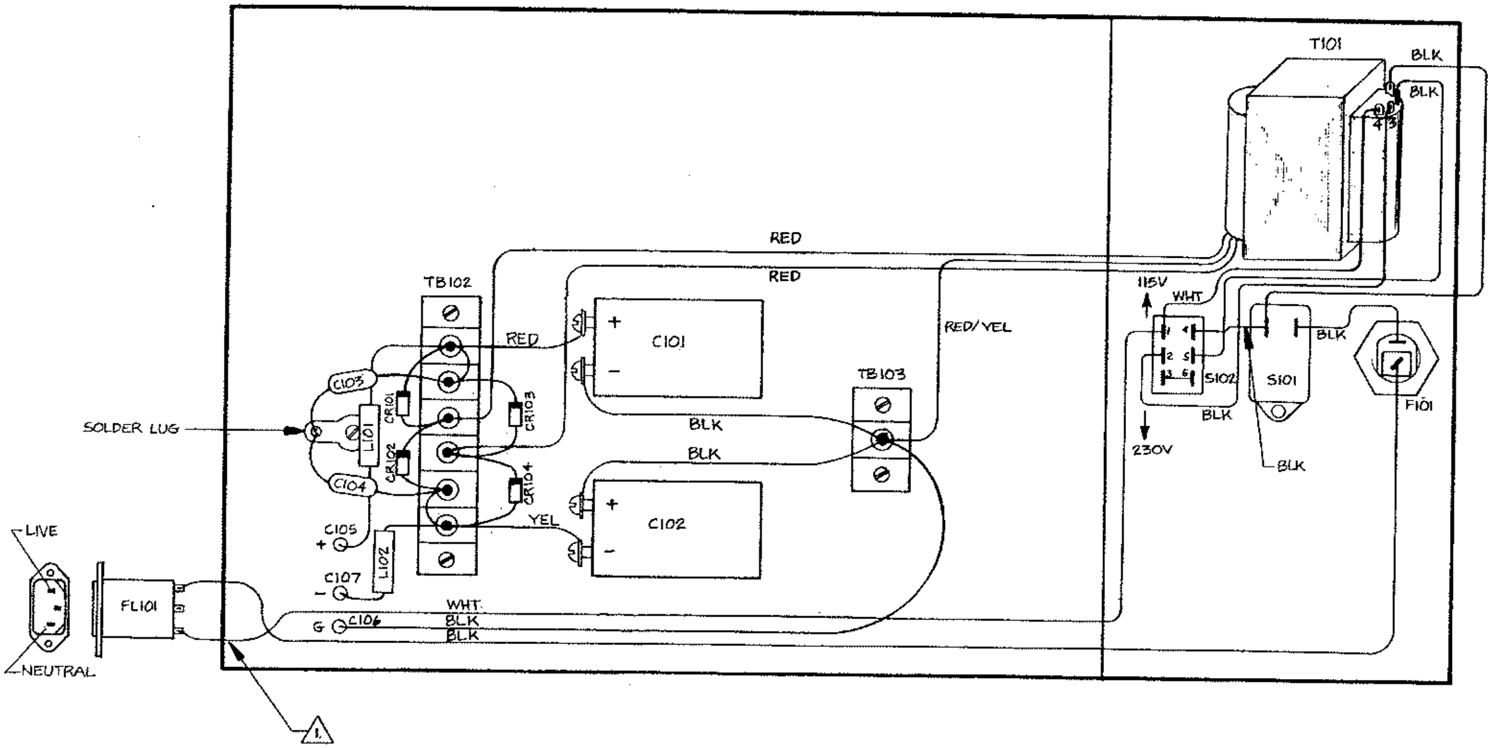
Schematic Drawings and Parts Locator Drawings for miscellaneous assemblies and the chassis interwiring follow.

TABLE OF CONTENTS

Notes

1) Chassis interwiring is indicated on the Schematics for the interconnected cards.
2) Connections for the Accessory Port and other such accessories are shown either in an Appendix of this manual or in a separate Supplemental Manual for the accessory.

J



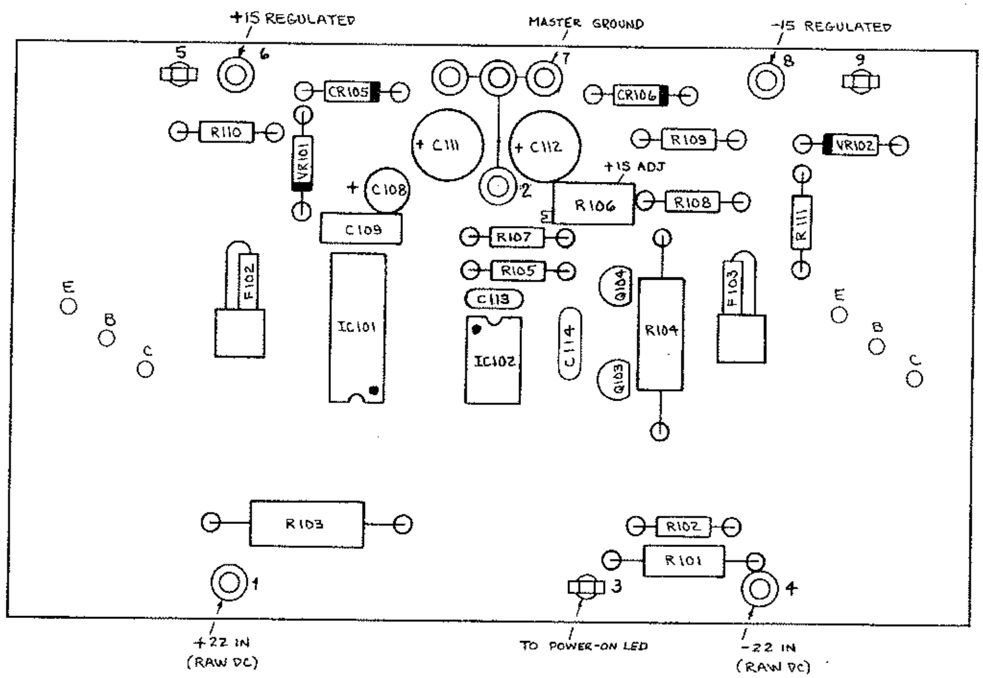
2. ALL WIRE USED IS 18 AWG UL1015 ONLY, 16/30 STRAND.

⚠1 TWIST WIRES SLIGHTLY TOGETHER.

NOTES: UNLESS OTHERWISE SPECIFIED.

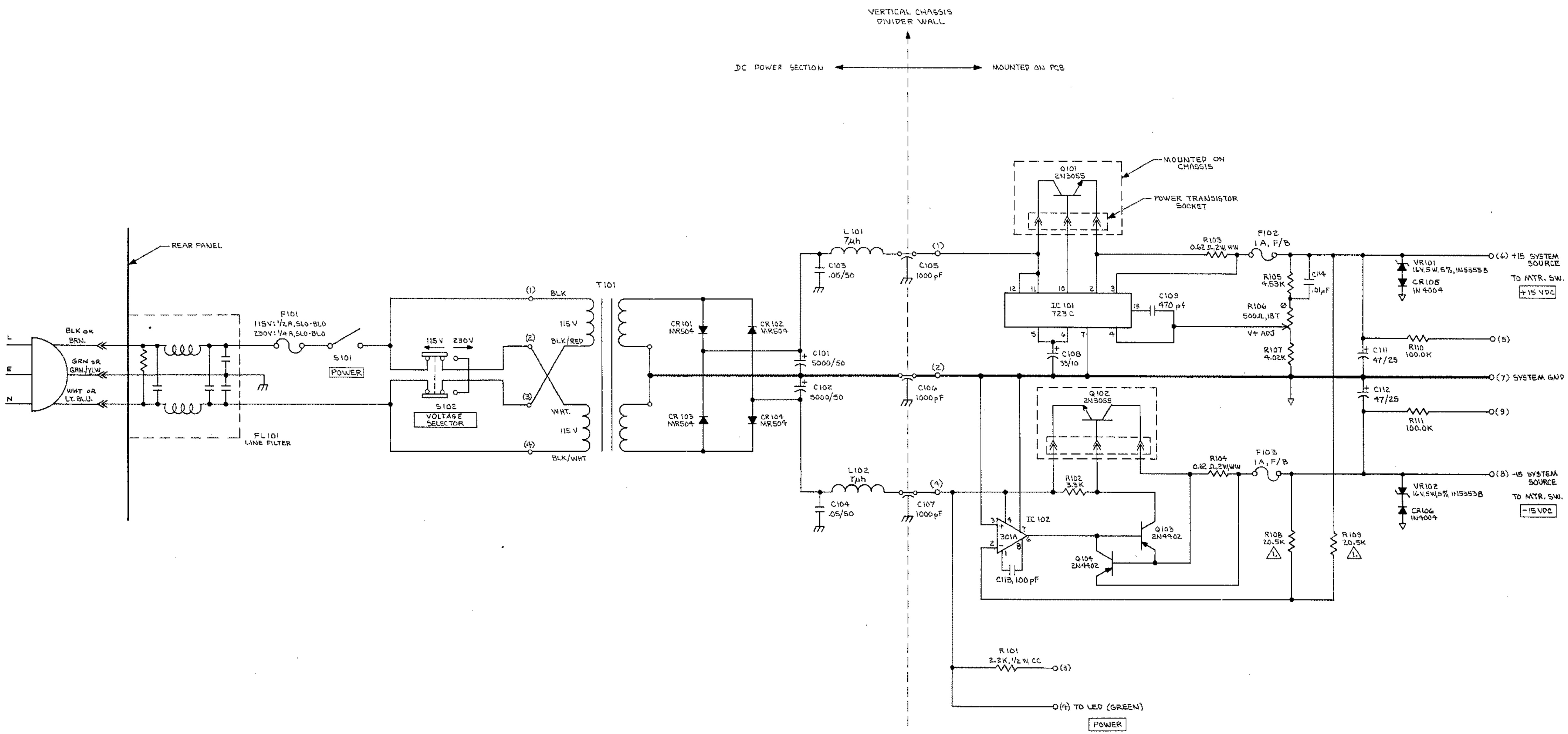
orban Orban Associates Inc.

TITLE: WIRING DIAGRAM DC POWER SUPPLY 60106-000-05



Orban Associates Inc.

TITLE: ASSEMBLY DRAWING
POWER SUPPLY REGULATOR
30310-000-06



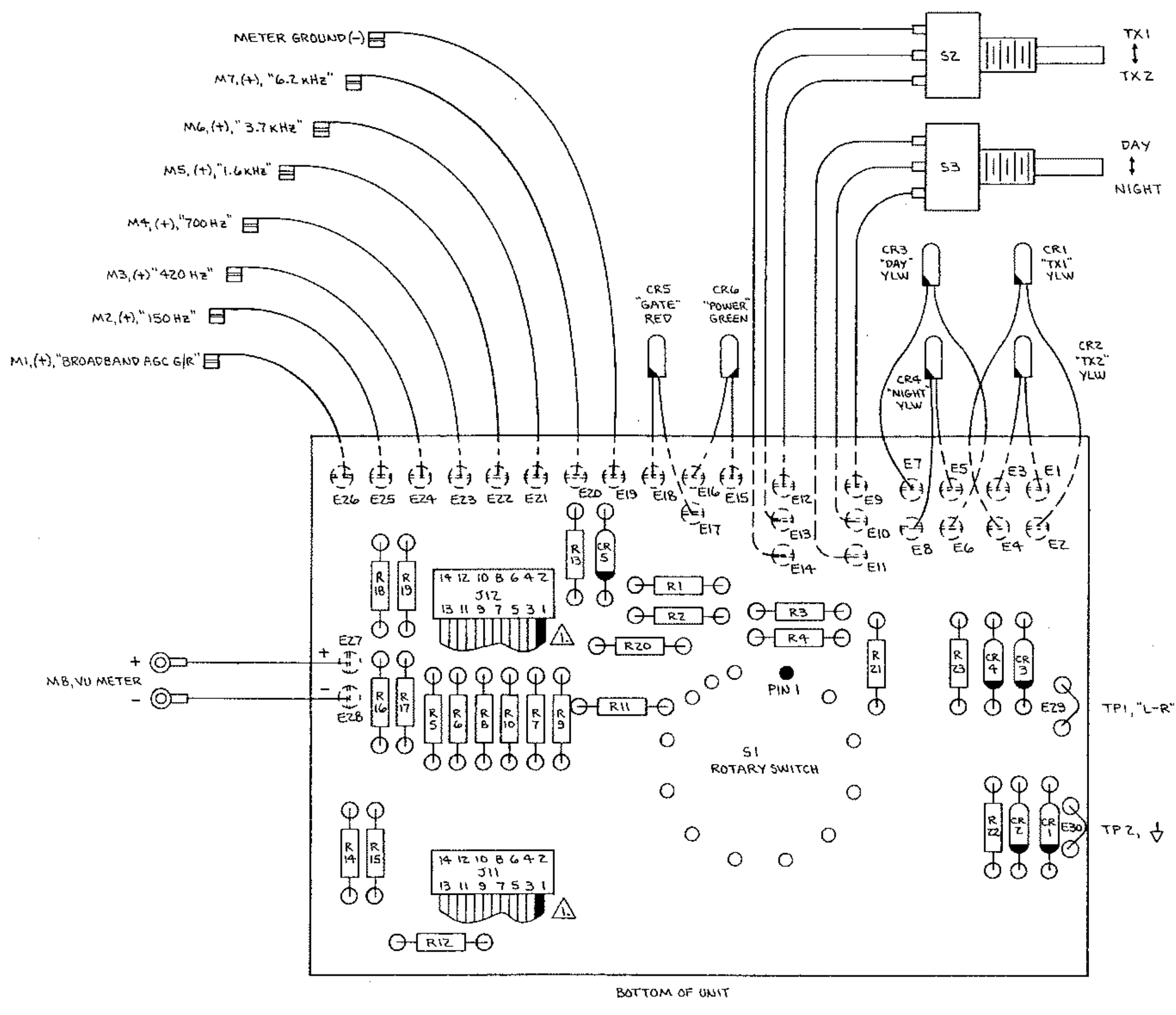
⚠ SELECTED: MATCHED TO 1/4%
NOTES:

REFERENCE DESIGNATORS		
ITEM	LAST USED	NOT USED
C	C114	C110
CR	106	—
IC	102	—
Q	104	—
R	111	—
S	102	—
VR	102	—
FL	101	—
T	101	—
L	102	—
F	103	—

orban Orban Associates Inc.

TITLE: SCHEMATIC
POWER SUPPLY REGULATOR
60021-000-05

J

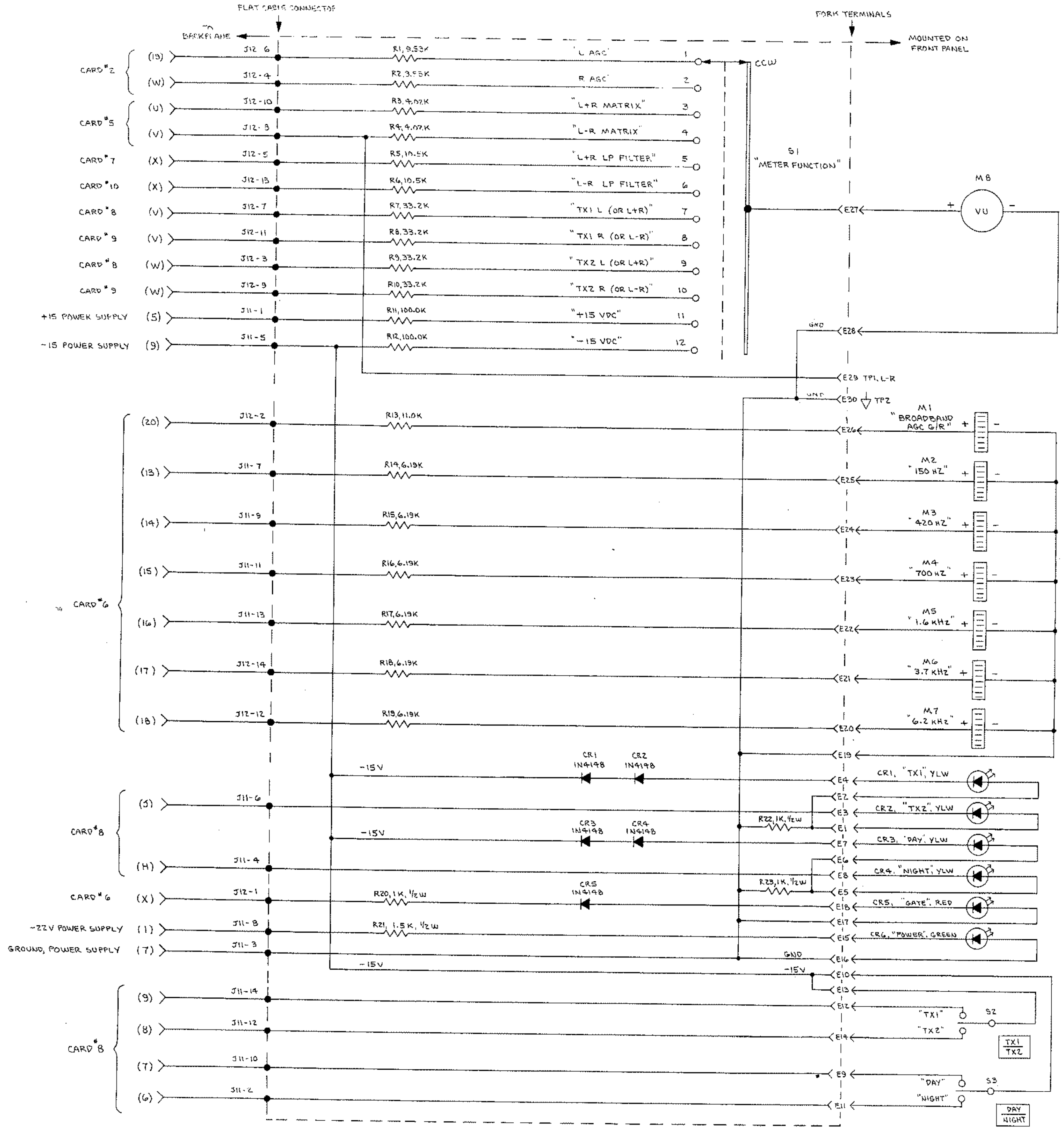


NOTES:

1. DARK BLUE LINE ON EDGE OF BERG RIBBON CABLE TO BE TOWARD PIN 1 ON 14 PIN CONNECTOR. J11 AND J12 TO BE INSTALLED ON FINAL ASSEMBLY.

Orban Associates Inc.

TITLE: ASSEMBLY DRAWING
METER RESISTOR ASSEMBLY
30605-000-01

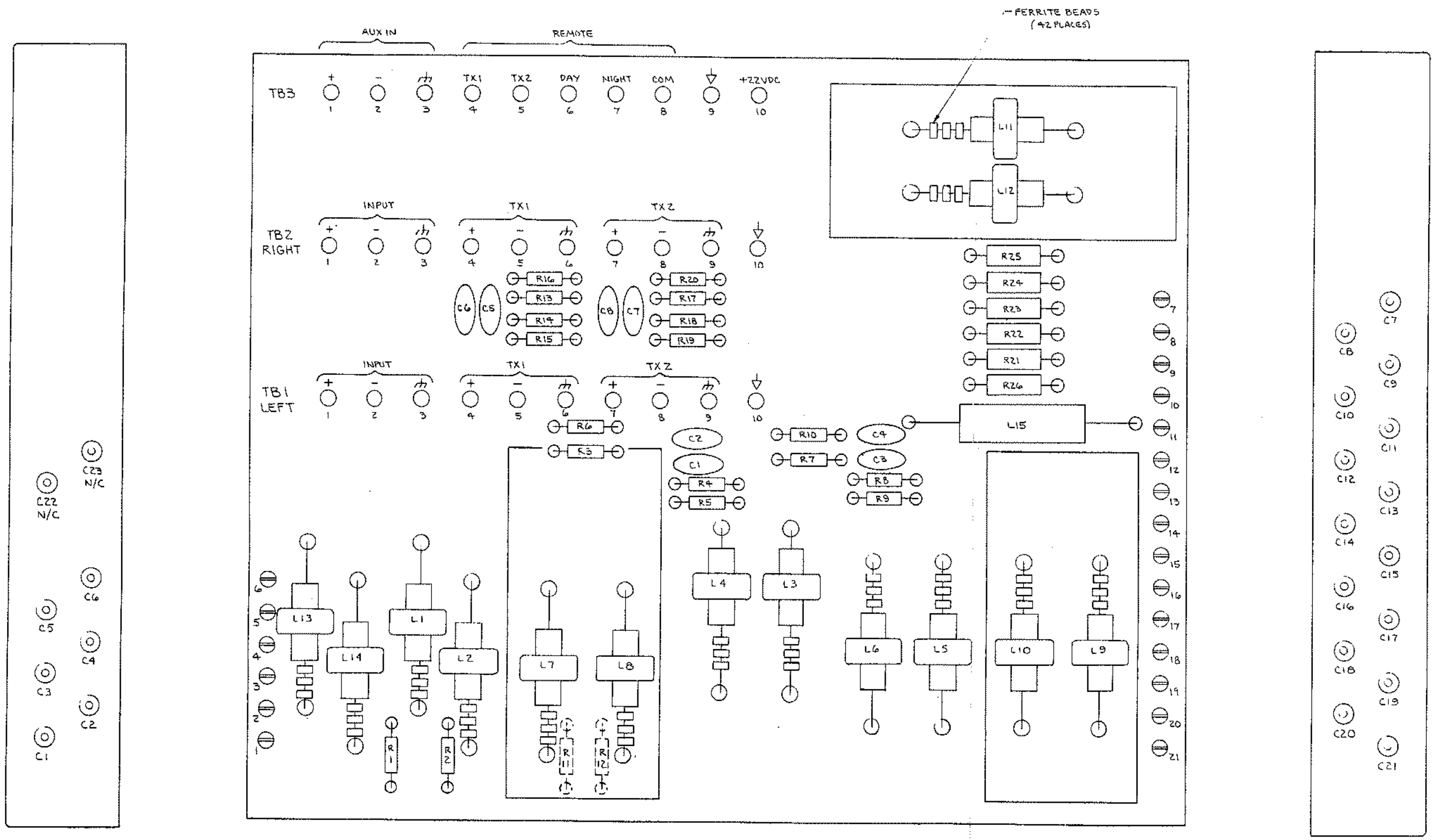


J

orban Orban Associates Inc.

TITLE:

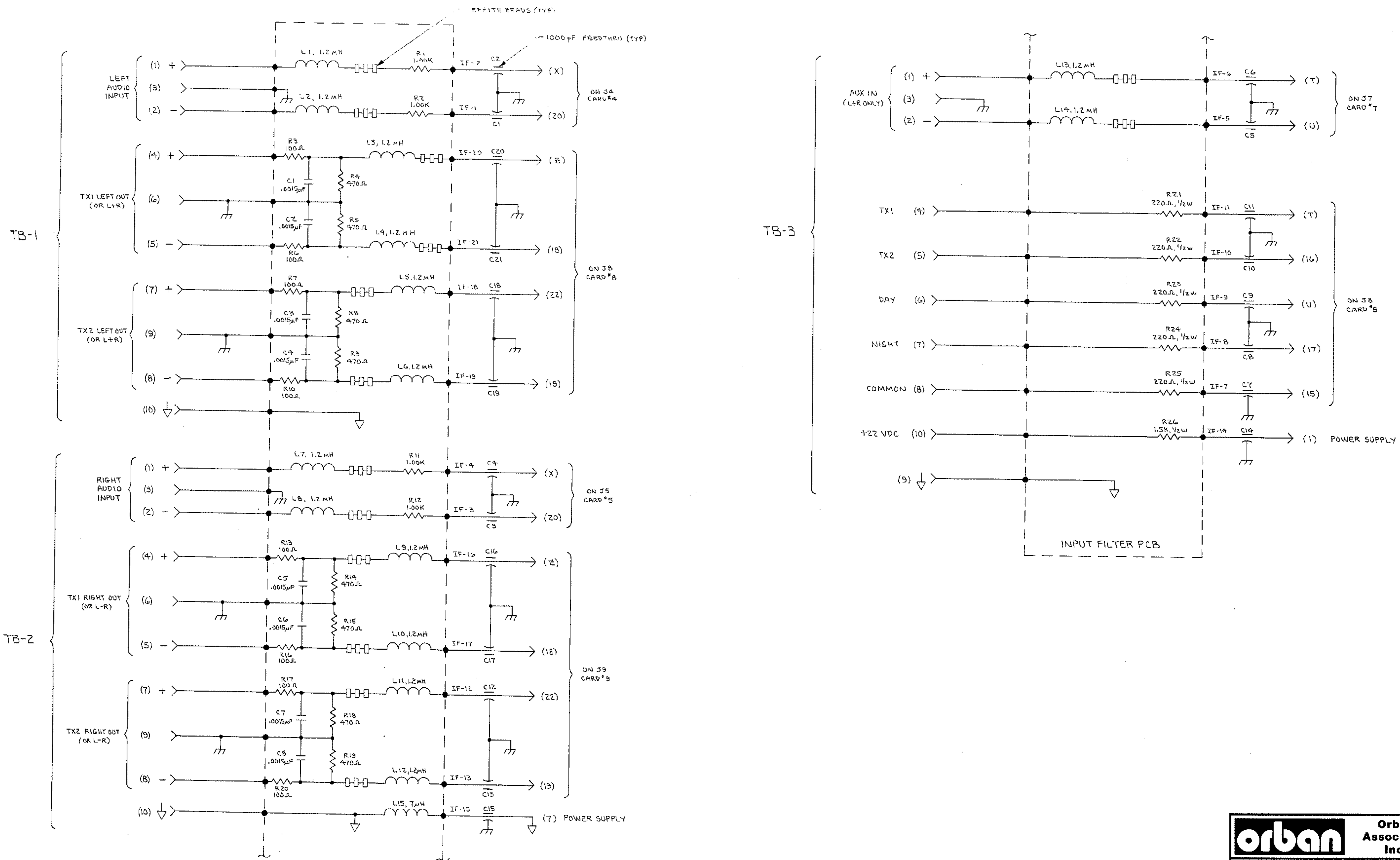
SCHEMATIC
METER RESISTOR ASSEMBLY
60060-000-01



TOP OF ASSY

orban Orban Associates Inc.

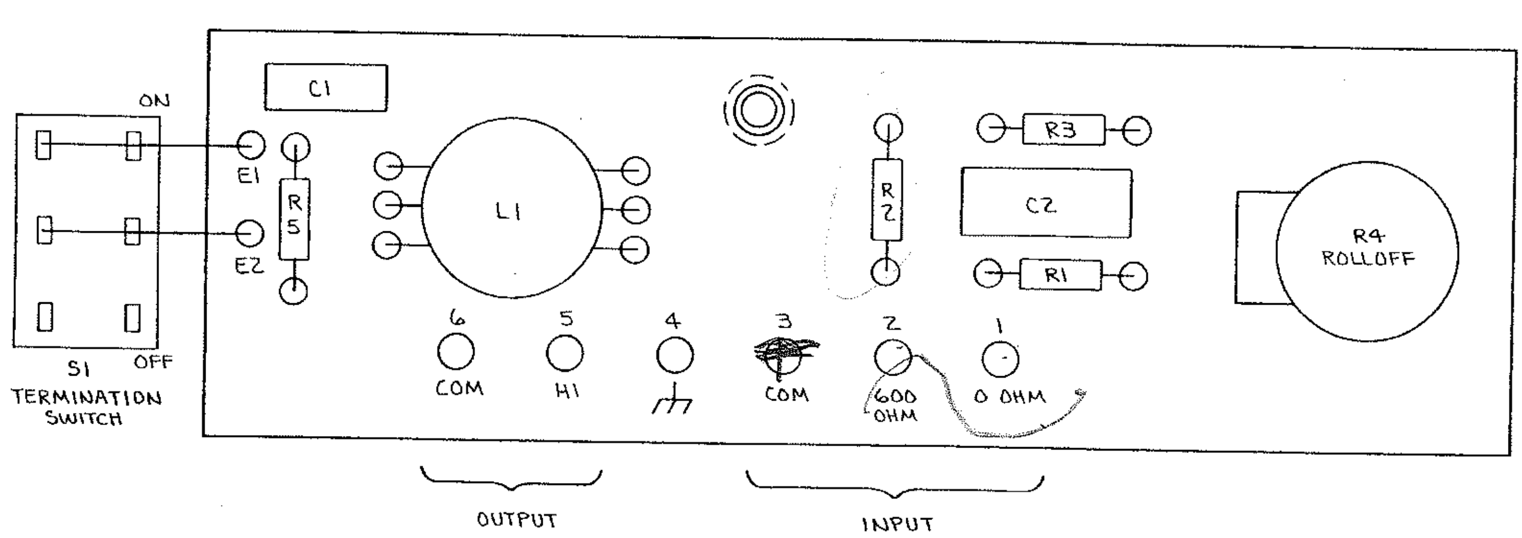
TITLE: ASSEMBLY DRAWING
INPUT FILTER ASSEMBLY
30620-000-02



orban Orban Associates Inc.

TITLE: SCHEMATIC
INPUT FILTER ASSEMBLY
60062-000-02

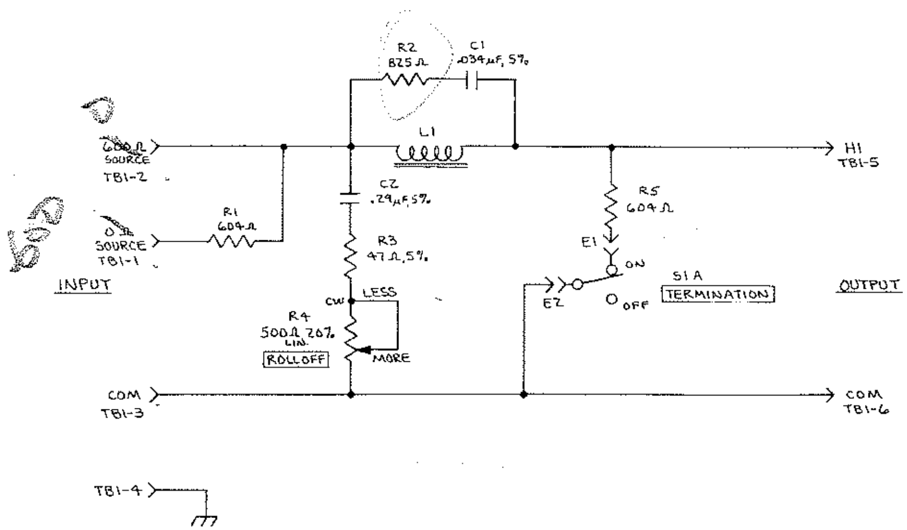
J



REAR VIEW

Orban Associates Inc.

TITLE: ASSEMBLY DRAWING
MONITOR ROLLOFF FILTER
30650-000-02



NOTES: UNLESS OTHERWISE SPECIFIED

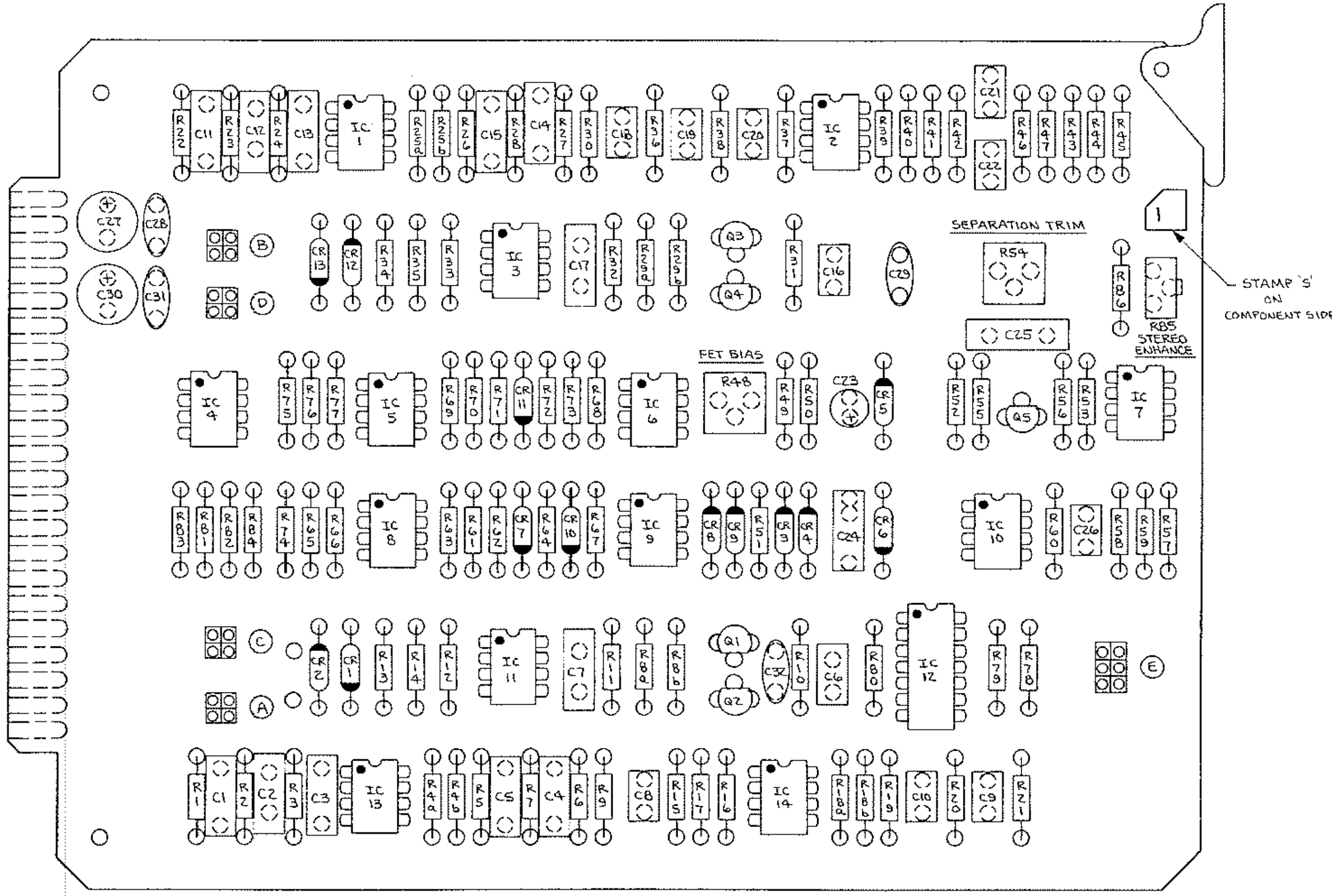
1. ALL RESISTORS ARE MF, 1/8 W, 1%.

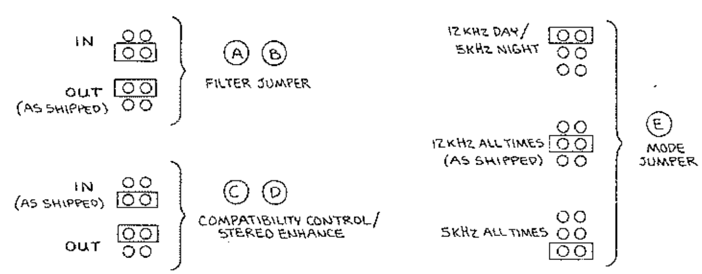
Orban Associates Inc.

TITLE: SCHEMATIC
MONITOR ROLLOFF FILTER
60059-000-01

J

	SIDE		
	SOLDER		COMPONENT
A	CHASSIS GND	1	——
B	+15V	2	——
C	GND	3	——
D	——	4	——
E	-15V	5	——
F	——	6	——
H	——	7	——
J	——	8	——
K	——	9	——
L	——	10	——
M	L-R OUT	11	——
N	L-R IN	12	——
P	——	13	——
R	——	14	——
S	——	15	——
T	NIGHT LOGIC	16	——
U	-4.1V	17	——
V	+4.1V	18	——
W	——	19	——
X	L+R OUT	20	——
Y	L+R IN	21	——
Z	——	22	——

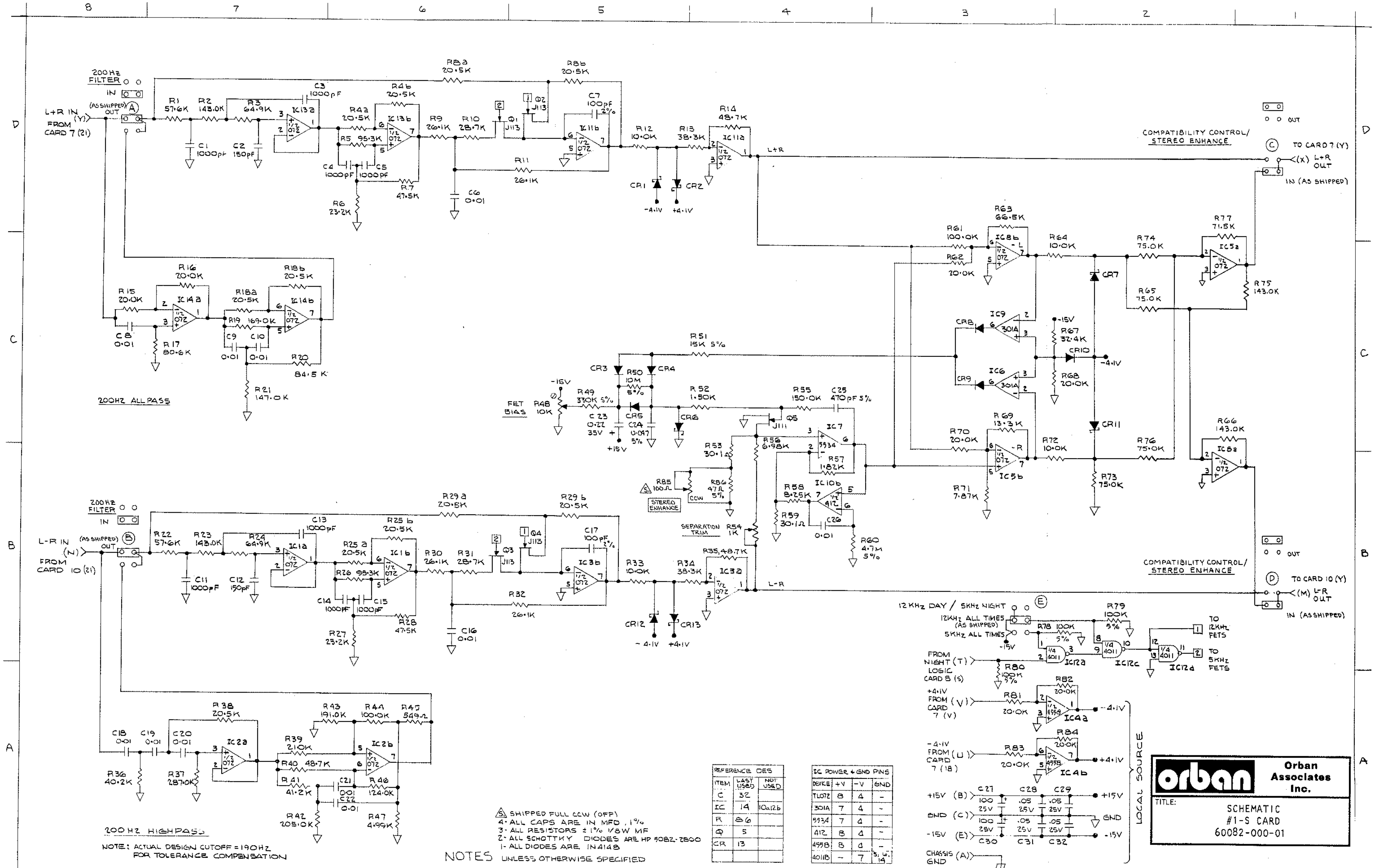




NOTES: UNLESS OTHERWISE SPECIFIED
1. REF. SCHEMATIC P/N 60082-000

Orban Associates Inc.

TITLE: ASSEMBLY DRAWING
#1-S CARD
30720-000-01



NOTES UNLESS OTHERWISE SPECIFIED

1- ALL DIODES ARE 1N4148
2- ALL SCHOTTKY DIODES ARE HP 5082-2800
3- ALL RESISTORS ±1% 1/8W MF
4- ALL CAPS ARE IN MFD, 1%
(5) SHIPPED FULL CCW (OFF)

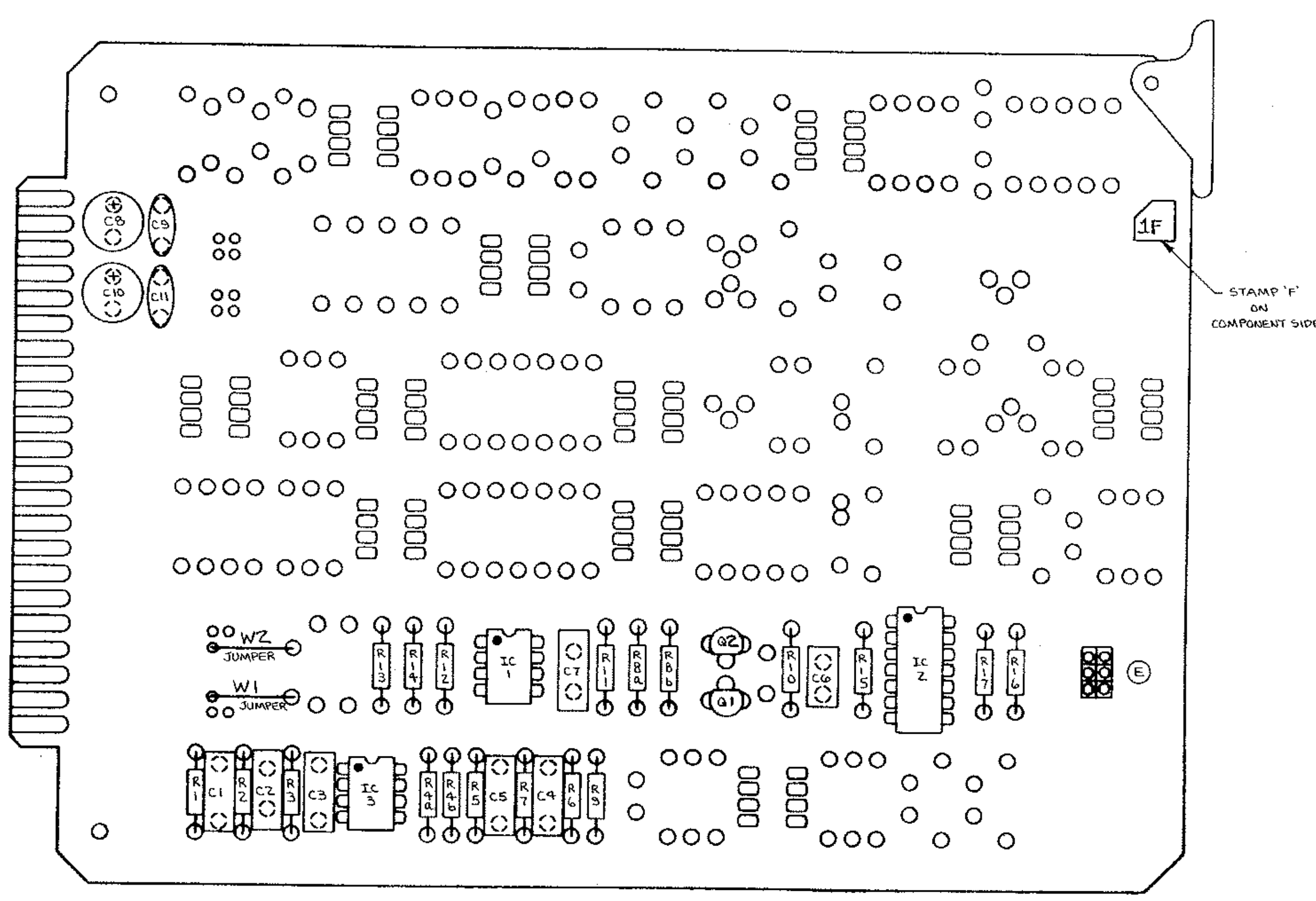
REFERENCE DES		
ITEM	LAST USED	NOT USED
C	32	
IC	14	10a12b
R	86	
Q	5	
CR	13	

IC POWER & GND PINS			
DEVICE	+V	-V	GND
TL072	8	4	-
301A	7	4	-
5534	7	4	-
412	8	4	-
4558	8	4	-
4011B	-	7	5, 6, 14

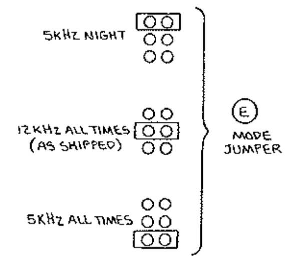
orban Orban Associates Inc.

TITLE: SCHEMATIC #1-S CARD 60082-000-01

J



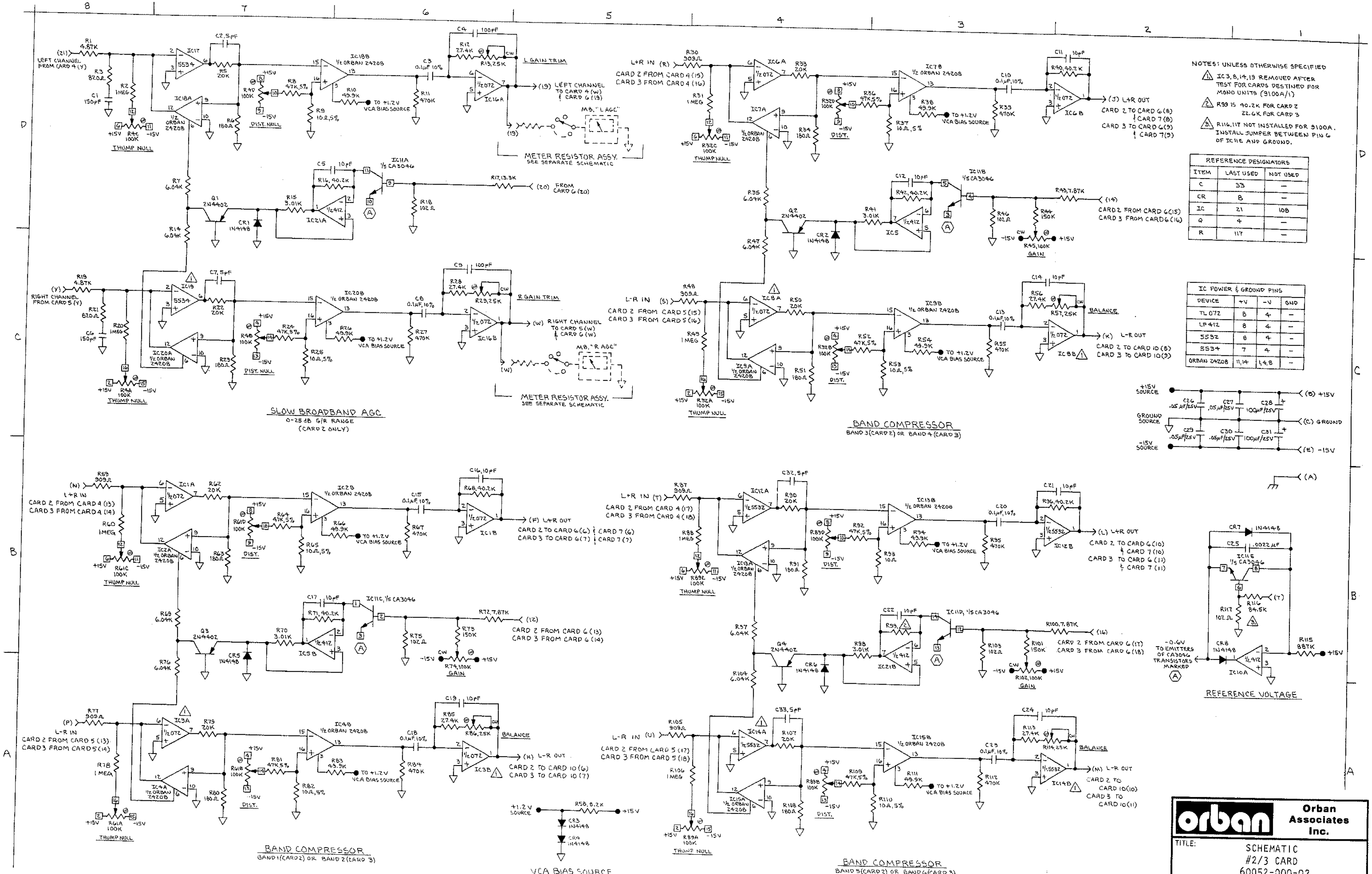
	SIDE		
	SOLDER		COMPONENT
A	CHASSIS GND	1	——
B	+15V	2	——
C	GND	3	——
D	——	4	——
E	-15V	5	——
F	——	6	——
H	——	7	——
J	——	8	——
K	——	9	——
L	——	10	——
M	——	11	——
N	——	12	——
P	——	13	——
R	——	14	——
S	——	15	——
T	NIGHT LOGIC	16	——
U	——	17	——
V	——	18	——
W	——	19	——
X	L+R OUT	20	——
Y	L+R IN	21	——
Z	——	22	——



3. TICK MARKS INDICATE PIN ONE OF IC'S, MODULES, CATHODE OF DIODES, POSITIVE SIDES OF CAPACITORS, EMITTER OF TRANSISTORS.
2. USE COMPONENT MTG. PADS, P/N 15051-000 FOR C8, C10.
1. REF. SCHEMATIC P/N 60083-000
NOTES: UNLESS OTHERWISE SPECIFIED

orban Orban Associates Inc.

TITLE: ASSEMBLY DRAWING
#1-F CARD
30725-000-01



NOTES: UNLESS OTHERWISE SPECIFIED

1. IC3, 8, 14, 19 REMOVED AFTER TEST FOR CARDS DESTINED FOR MONO UNITS (9100A/1)
2. R99 IS 40.2K FOR CARD 2, 22.6K FOR CARD 3
3. R116, 117 NOT INSTALLED FOR 9100A. INSTALL JUMPER BETWEEN PIN 6 OF IC11E AND GROUND.

REFERENCE DESIGNATORS		
ITEM	LAST USED	NOT USED
C	33	—
CR	8	—
IC	21	10B
Q	4	—
R	117	—

IC POWER & GROUND PINS			
DEVICE	+V	-V	GND
TL072	8	4	—
LF412	8	4	—
5532	8	4	—
5534	7	4	—
ORBAN 24208	11, 14	1, 4, 8	—

orban

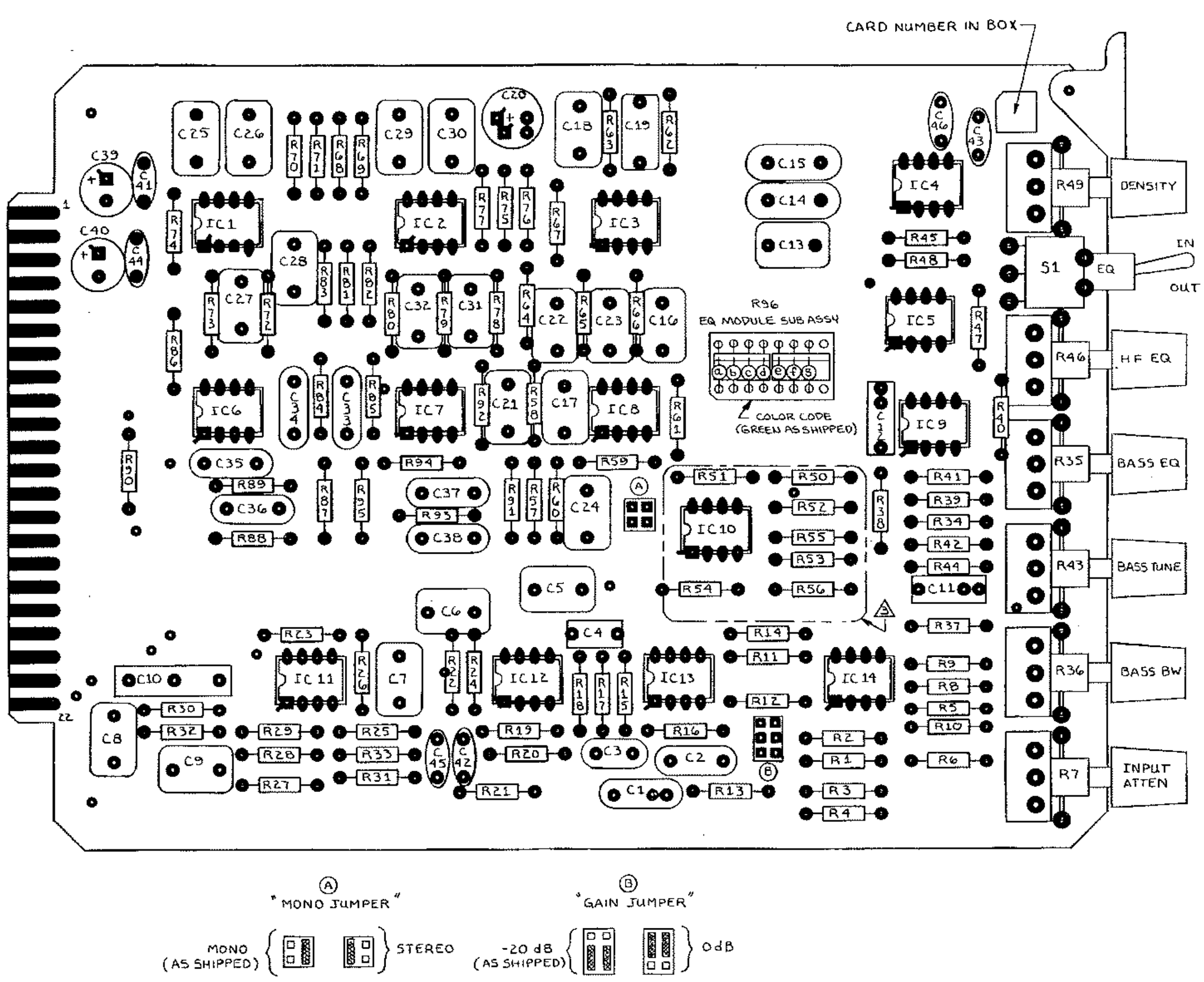
Orban Associates Inc.

TITLE: SCHEMATIC #2/3 CARD 60052-000-02

J

	SOLDER	SIDE	COMPONENT
A		1	
B	+15V	2	
C	GND	3	
D		4	
E	-15V	5	
F		6	
H		7	
J		8	
K		9	
L		10	
M		11	
N		12	
P		13	[4 L+R, 5 L+R] COMP OUT BAND 1
R		14	[4 L+R, 5 L+R] COMP OUT BAND 2
S	MATRIX IN	15	[4 L+R, 5 L+R] COMP OUT BAND 3
T	MATRIX IN	16	[4 L+R, 5 L+R] COMP OUT BAND 4
U	[4 L+R, 5 L+R] MATRIX OUT	17	[4 L+R, 5 L+R] COMP OUT BAND 5
V	[4 L+R, 5 L+R] MATRIX OUT	18	[4 L+R, 5 L+R] COMP OUT BAND 6
W	[4 L, 5 R] BBD AGC OUT	19	
X	[4 L, 5 R] AUDIO IN HI	20	[4 L, 5 R] AUDIO IN LO
Y	[4 L, 5 R] HP FILTER OUT	21	
Z		22	[4 L+R, 5 L+R] XOVER OUT

MNEMONICS IN BRACKETS LISTED ABOVE INDICATE ; [4 CARD / 5 CARD]



NOTES:

1. REF SCHEMATIC: #60054-000.
2. VERSIONS: -001 = 4 CARD, -002 = 5 CARD.
3. LOAD ON 5 CARD ONLY. (9100A/2)
4. USE COMP. MTG. PADS FOR C20,39,40.

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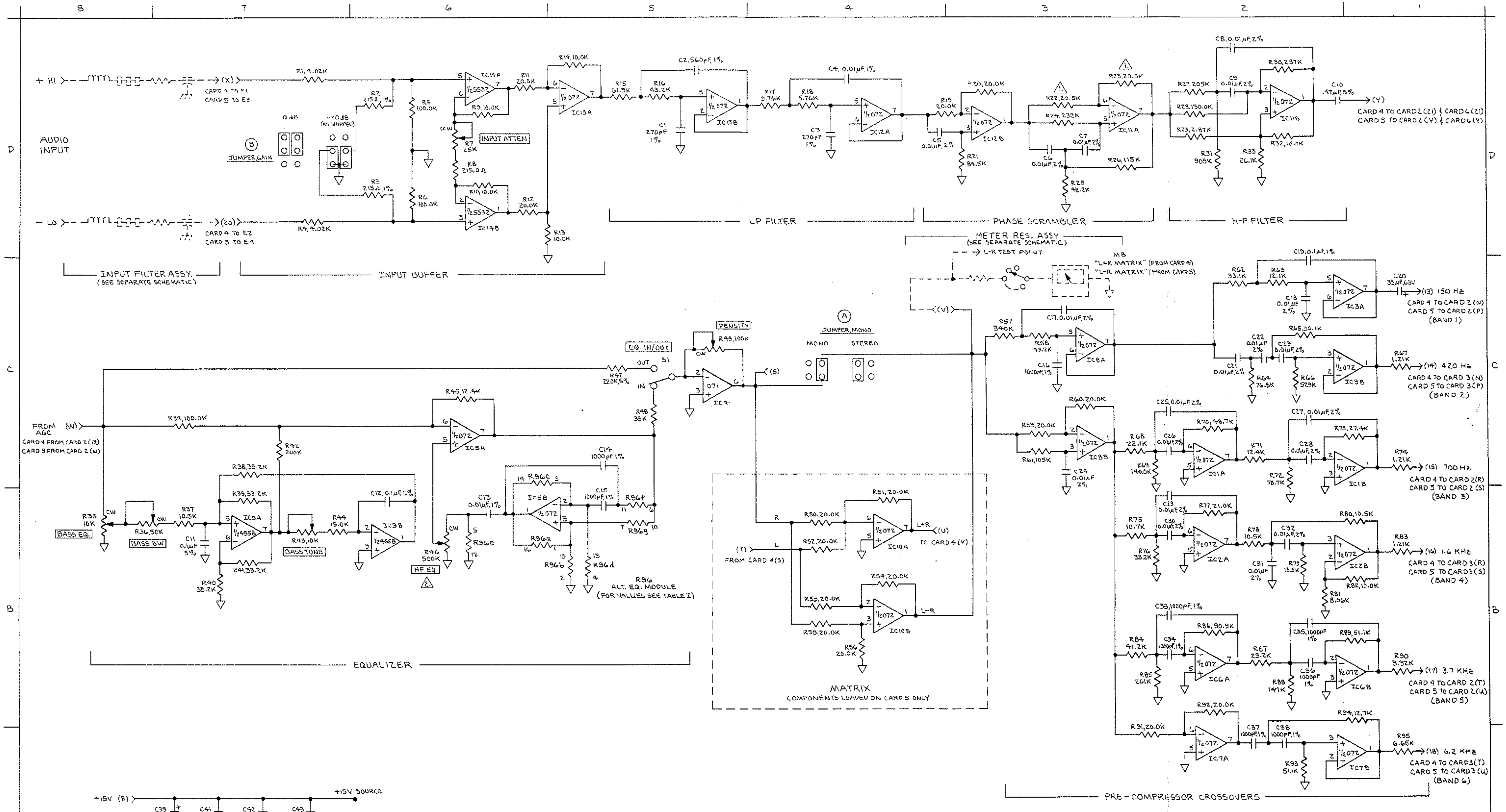
TITLE ASSEMBLY DRAWING #4/5 CARD 30640-VER-04



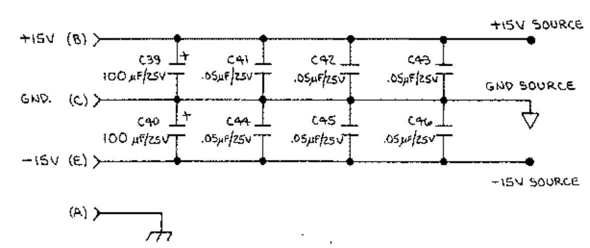


TABLE I

DESCRIPTION	RESISTOR VALUES a	b	c	d	e	f	g
GRN. = STANDARD	10.0K	14.0K	57.6K	137.0K	6.65K	53.6K	4.12K
YEL. = COMPROMISE	10.0K	137.0K	29.4K	374.0K	6.65K	93.1K	34.0K
RED = TRANSITIONAL AM STEREO	10.0K	44.2K	44.2K	205.0K	6.65K	66.5K	10.5K

REFERENCE DESIGNATORS		
ITEM	LAST USED	NOT USED
C	46	—
IC	14	—
R	96	—
S	1	—

IC POWER & GROUND PINS			
DEVICE	+V	−V	GND
TL072	8	4	—
4558	8	4	—
5532	8	4	—
TL071	7	4	—

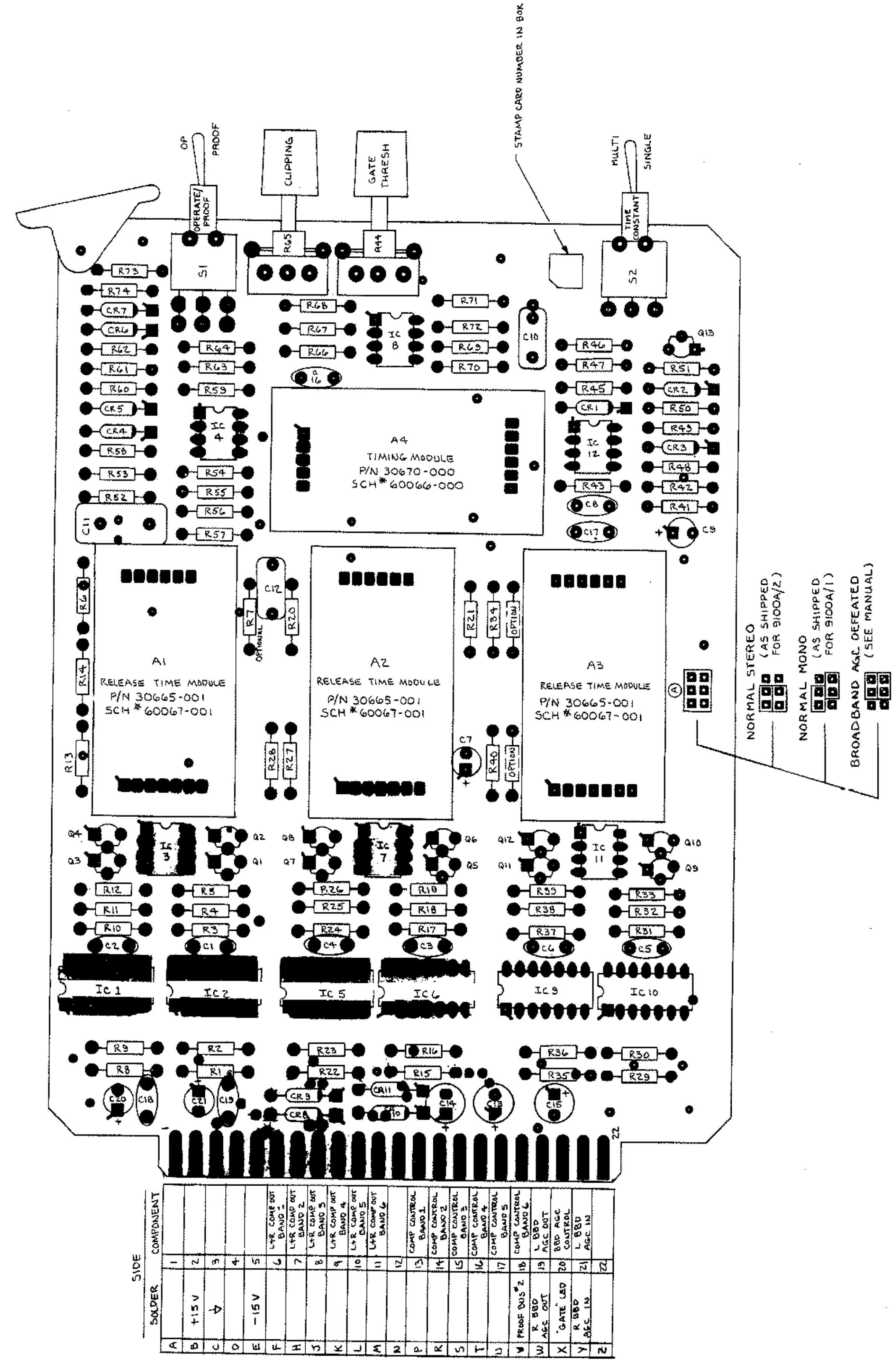
CARD #4: L+R (OR MONO)
CARD #5: L−R

⚠2 PATENT PENDING ON HF EQUALIZER CIRCUIT.
⚠1 SELECTED
NOTES: UNLESS OTHERWISE SPECIFIED

Orban Associates Inc.

TITLE: SCHEMATIC #4/5 CARD 60054-000-02

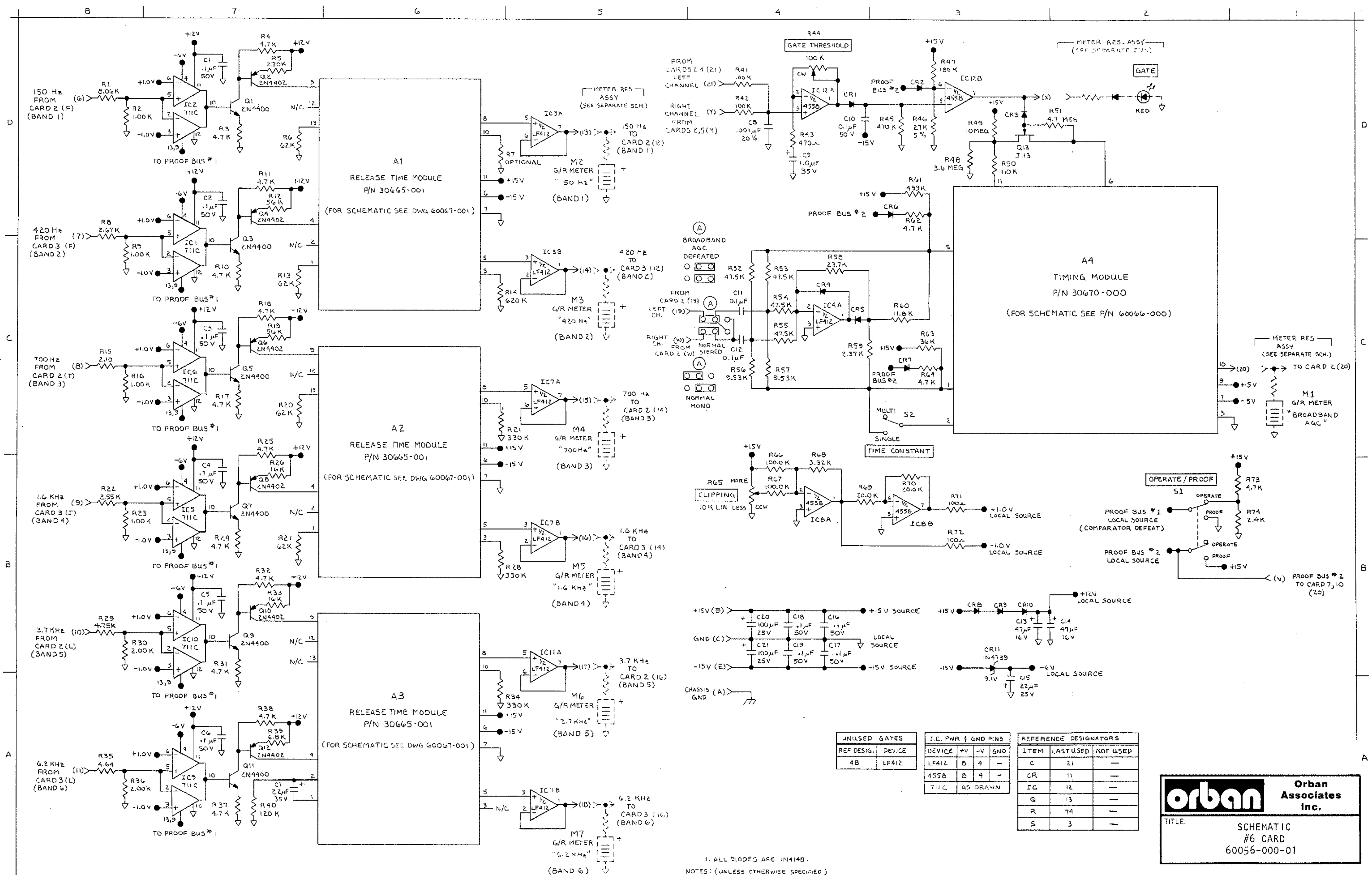
J



Orban Associates Inc.

TITLE ASSEMBLY DRAWING
#6 CARD
30660-000-03

NOTES:
1. REF. SCHEMATIC #60056-000.



UNUSED GATES	
REF DESIG.	DEVICE
4B	LF412

I.C. PWR & GND PINS			
DEVICE	+V	-V	GND
LF412	8	4	—
4558	8	4	—
711C	AS DRAWN		

REFERENCE DESIGNATORS		
ITEM	LAST USED	NOT USED
C	21	—
CR	11	—
IC	12	—
Q	13	—
R	74	—
S	3	—

NOTES: (UNLESS OTHERWISE SPECIFIED)

1. ALL DIODES ARE IN4148.

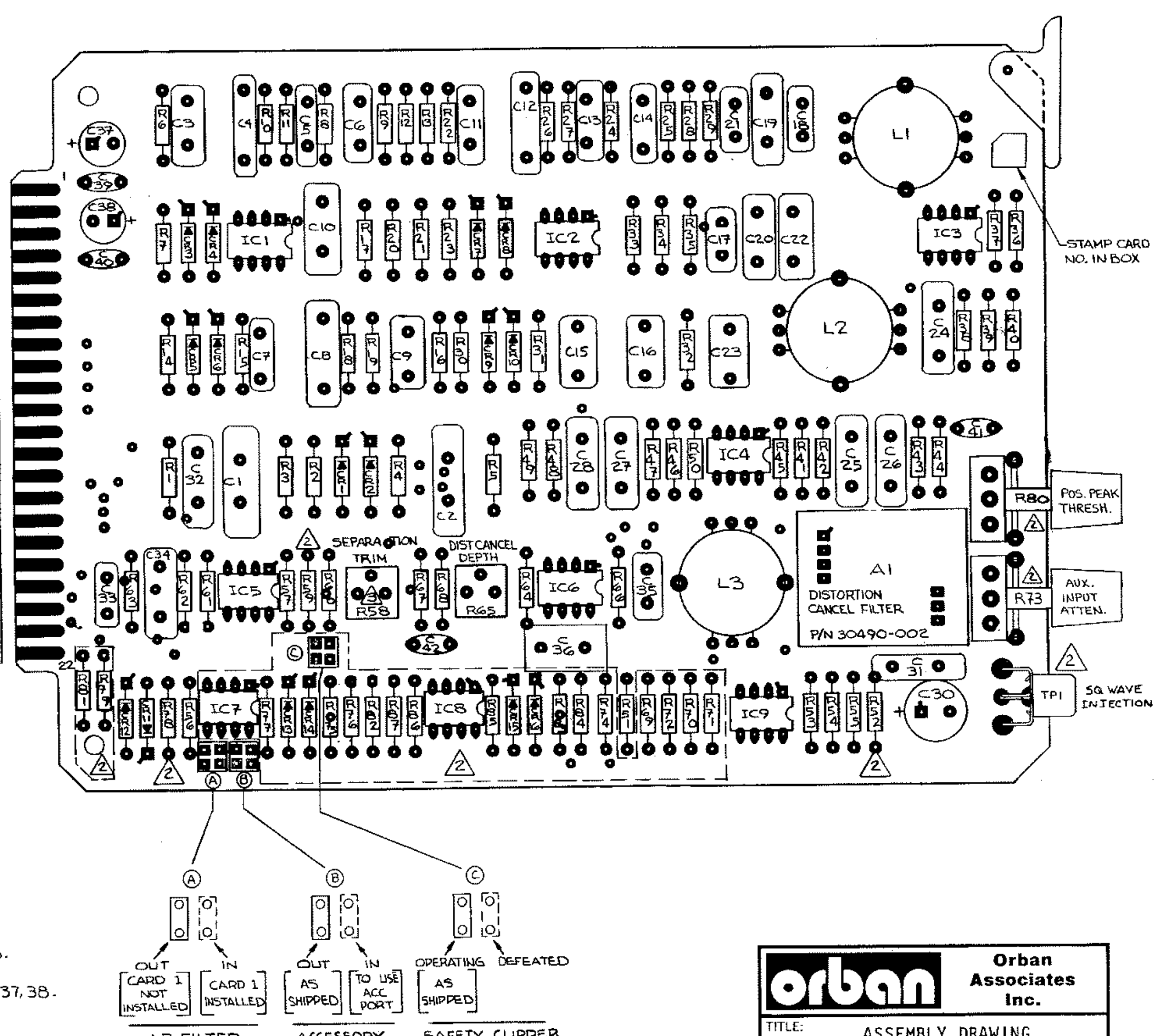
Orban Associates Inc.

TITLE: SCHEMATIC #6 CARD 60056-000-01

J

SIDE	SOLDER /		COMPONENT
A	CHASSIS GND	1	–
B	+15V	2	–
C	SIGNAL GND	3	–
D		4	–
E	-15V	5	–
F	[L+R / L-R] CARD OUT	6	BAND 1 [L+R / L-R] COMP OUT
H	–	7	BAND 2 [L+R / L-R] COMP OUT
J	–	8	BAND 3 [L+R / L-R] COMP OUT
K	–	9	BAND 4 [L+R / L-R] COMP OUT
L	–	10	BAND 5 [L+R / L-R] COMP OUT
M	[L-R] FROM LP FILTER	11	BAND 6 [L+R / L-R] COMP OUT
N	–	12	–
P	METER "LP FILTER"	13	–
R	–	14	–
S	–	15	–
T	AUX IN (+)	16	–
U	AUX IN (-)	17	–
V	+4.1V	18	-4.1V
W	+1.8V	19	-1.8V
X	METER "LP FILTER"	20	PROOF BUS #2
Y	[L+R] FROM LP FILTER	21	[L+R / L-R] TO LP FILTER
Z	–	22	–

MNEMONICS IN BRACKETS LISTED ABOVE INDICATE [(7 CARD) / (10 CARD)]



5. REF SCHEMATIC P/N 60057-000.
4. USE COMP. MTG PADS FOR C30, 37, 38.
⚠3 NOT LOADED ON 7 CARD.
⚠2 NOT LOADED ON 10 CARD.
1. VER -001 = 7 CARD
   -002 = 10 CARD

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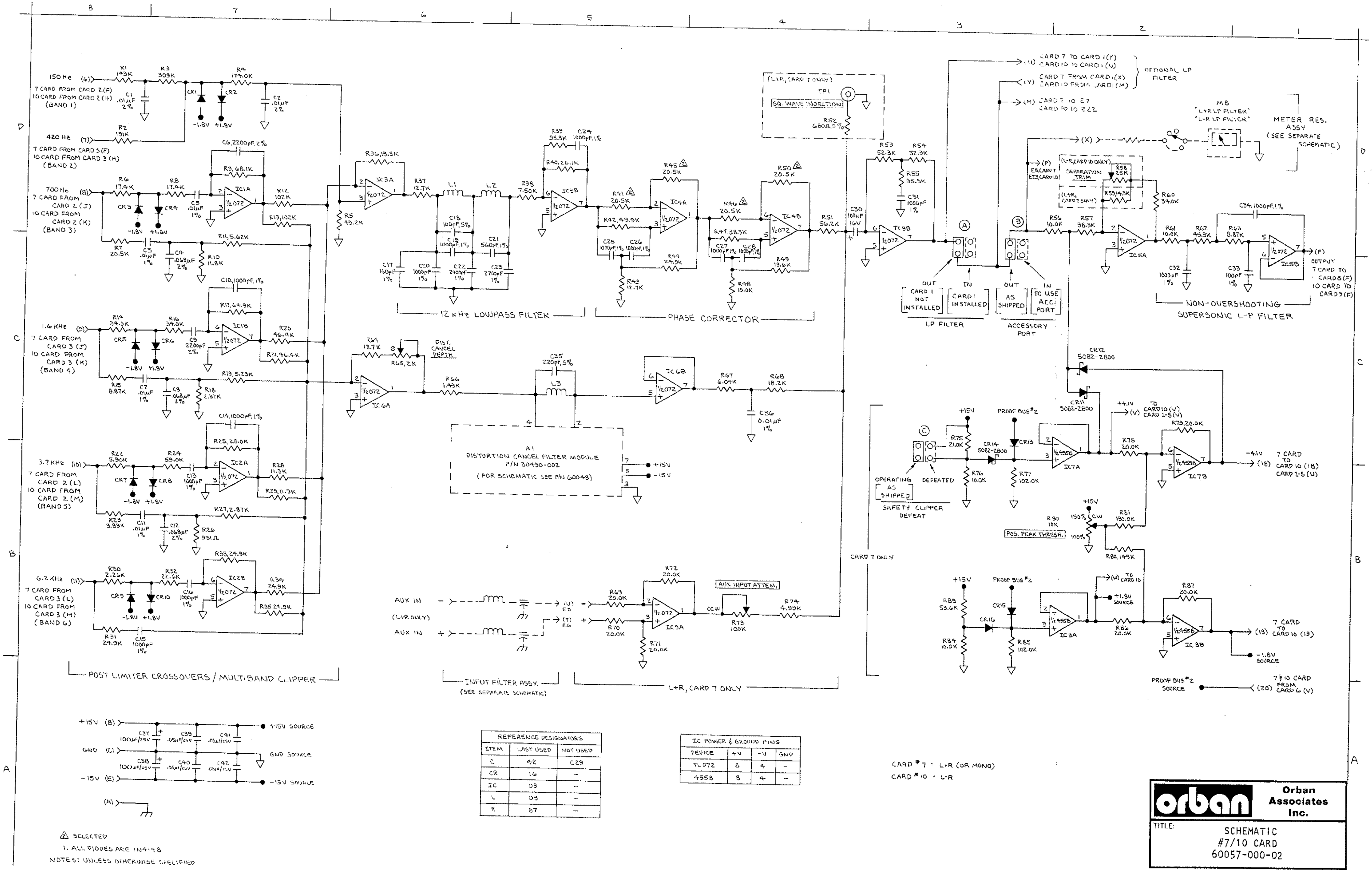
TITLE: ASSEMBLY DRAWING #7/10 CARD 30700-VER-03



REFERENCE DESIGNATORS

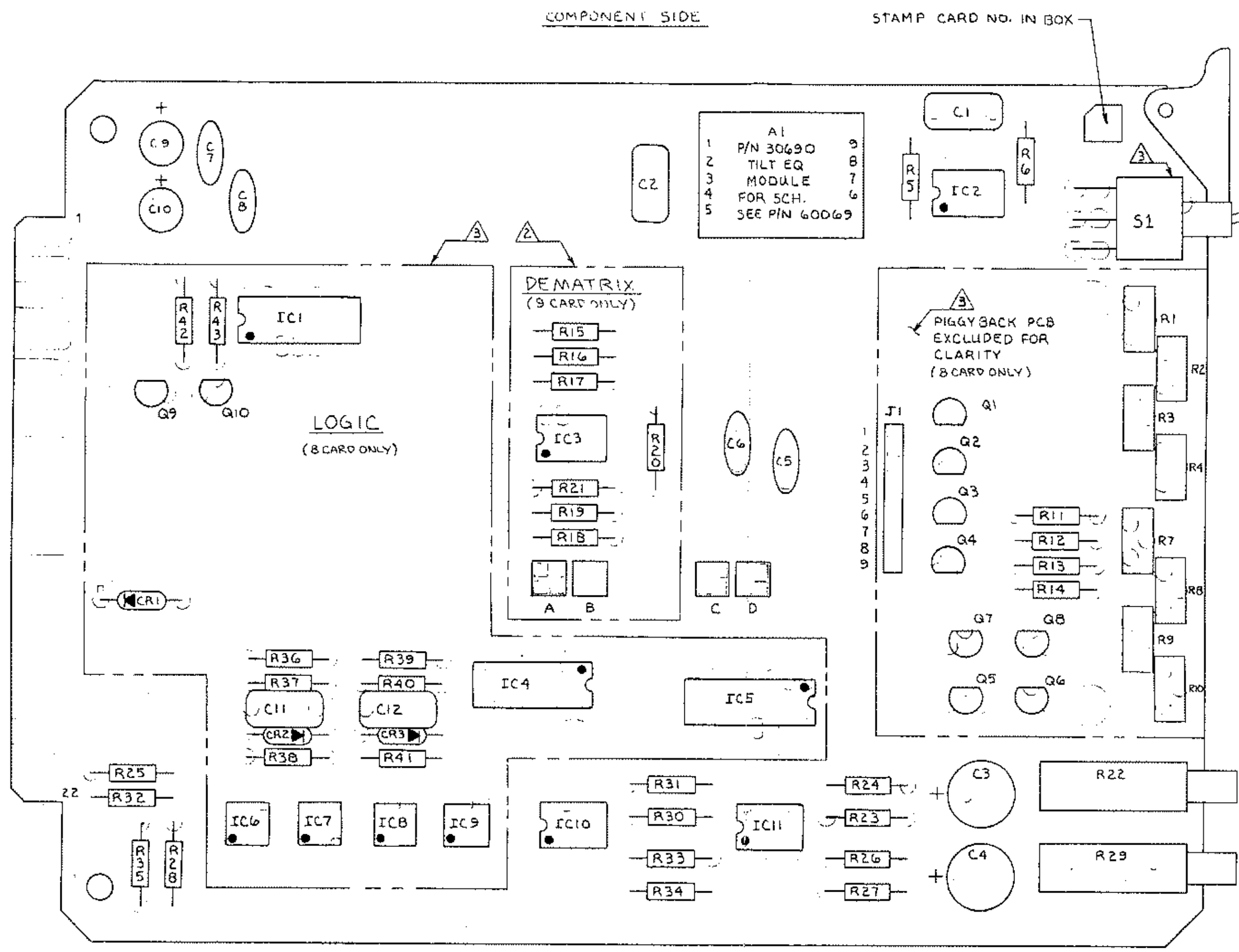
ITEM	LAST USED	NOT USED
C	42	C29
CR	16	–
IC	09	–
L	03	–
R	87	–

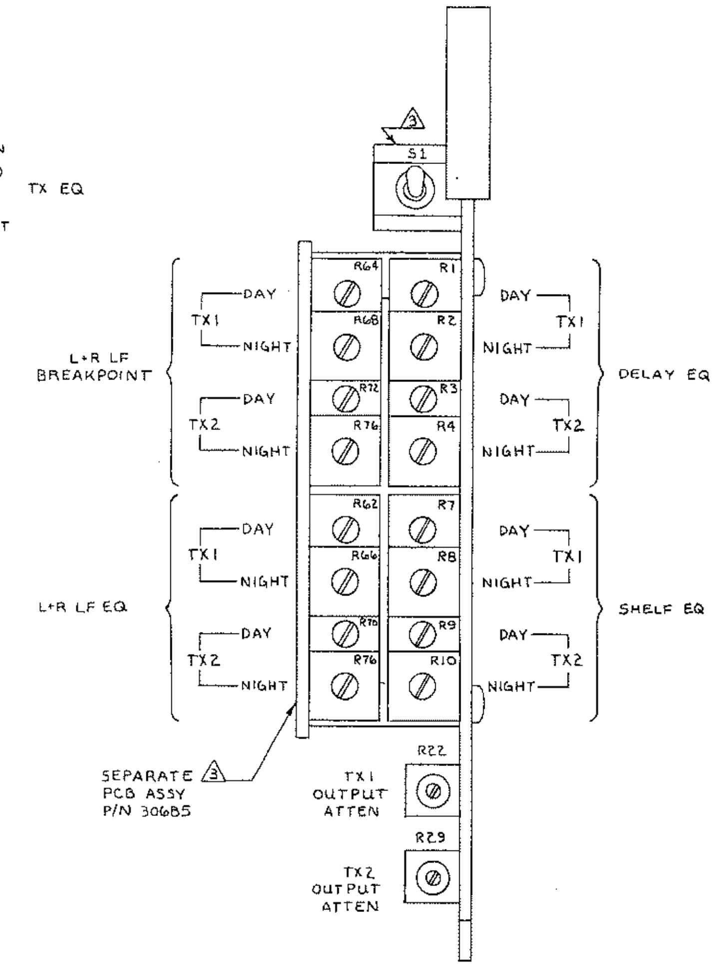
IC POWER & GROUND PINS

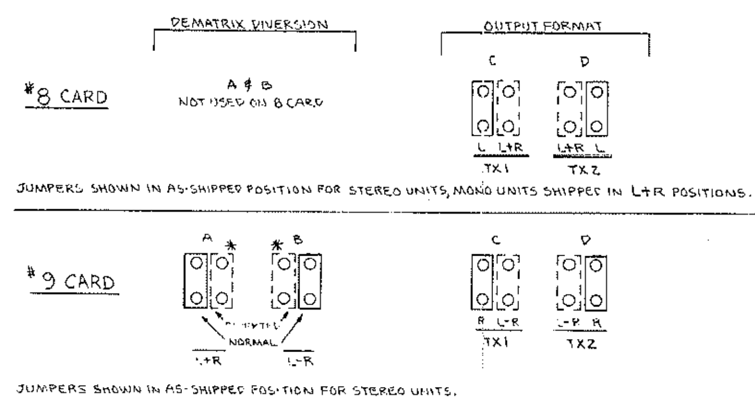
DEVICE	+V	-V	GND
TL072	8	4	–
4558	8	4	–

	SOLDER SIDE		COMPONENT SIDE
A	CHASSIS GND	1	————
B	+15V	2	————
C	GND	3	————
D	LOGIC GND	4	————
E	-15V	5	————
F	[L+R / L-R] LP FILTER OUT	6	[SWITCH NIGHT]
H	[LED NIGHT]	7	[SWITCH DAY]
J	[LED TX2]	8	[SWITCH TX2]
K	L-R TX EQ IN	9	[SWITCH TX1]
L	L-R TX EQ IN	10	————
M	L+R DE-MATRIX IN	11	L-R TX EQ OUT
N	L+R DE-MATRIX IN	12	L-R TX EQ OUT
P	DE-MATRIX OUT	13	L-R DEMATRIX IN
R	DE-MATRIX OUT	14	L-R DEMATRIX IN
S	NIGHT LOGIC	15	LOGIC INPUT COM
T	LOGIC INPUT TX1	16	LOGIC INPUT TX2
U	LOGIC INPUT DAY	17	LOGIC INPUT NIGHT
V	METER OUT TX1	18	[LEFT / RIGHT] TX1 LO
W	METER OUT TX2	19	[LEFT / RIGHT] TX2 LO
X	DAY TX1	20	NIGHT TX1
Y	DAY TX2	21	NIGHT TX2
Z	[LEFT / RIGHT] TX1 HI	22	[LEFT / RIGHT] TX2 HI

MNEMONICS IN BRACKETS LISTED ABOVE INDICATE [(8 CARD) / (9 CARD)]







* WHEN DE-MATRIX JUMPERS ARE IN DIVERTED POSITION, THE DE-MATRIX IS ACCESSIBLE FROM BACKPLANE FORK TERMINALS.

6. 9 CARD NOT INSTALLED IN 8100A/1 (MONO UNIT).
5. USE COMPONENT MOUNTING PADS FOR C3, 4, 9, 10.
4. REF SCHEMATIC P/N 60058-000 (8 CARD), 60063-000 (9 CARD)
3. NOT LOADED ON 9 CARD
2. NOT LOADED ON 8 CARD
1. VER-001 = 8 CARD
   VER-002 = 9 CARD

NOTES: UNLESS OTHERWISE SPECIFIED

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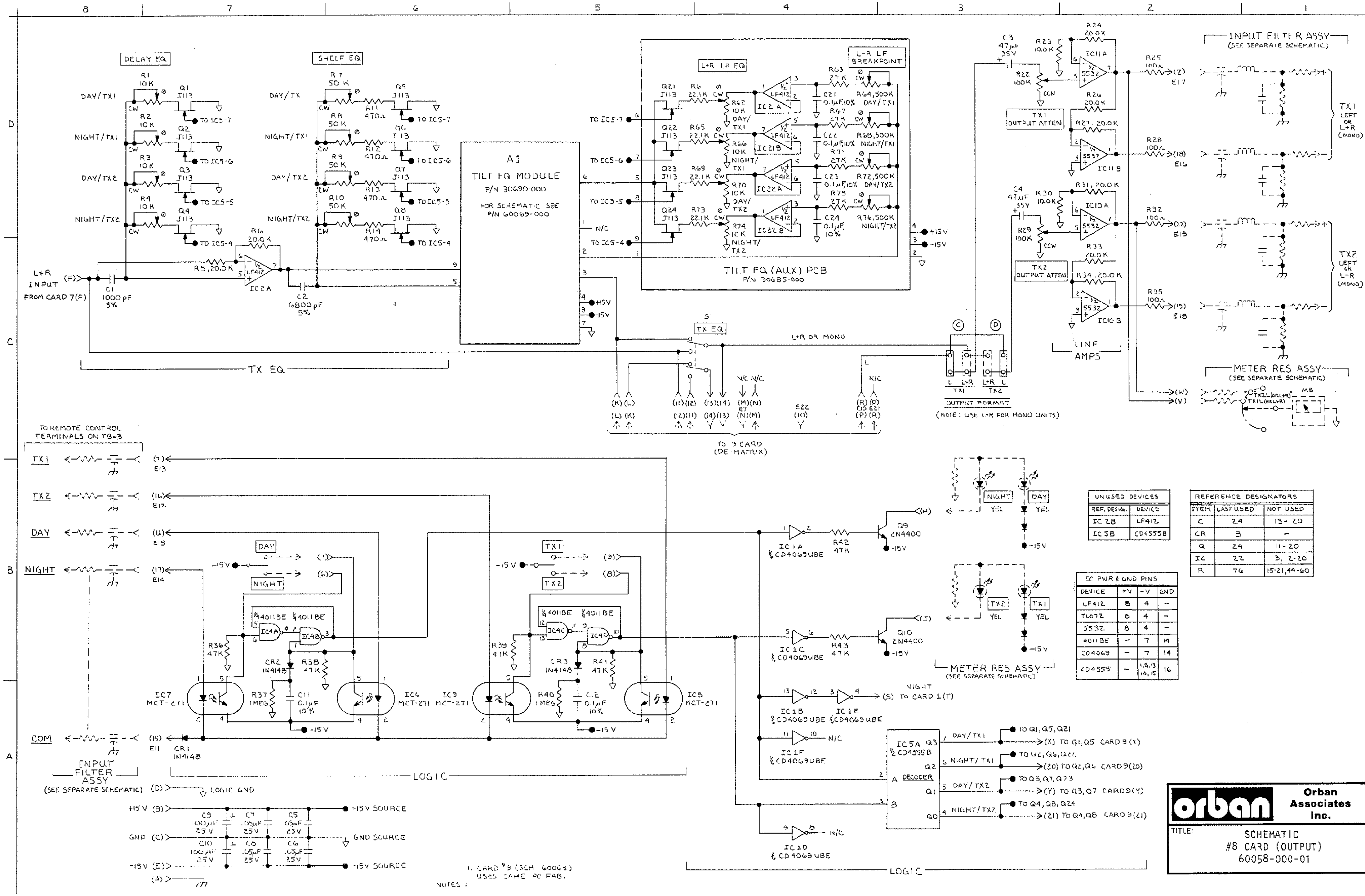
TITLE: ASSEMBLY DRAWING
#8/9 CARD
30680-VER-02



UNUSED DEVICES	
REF. DESIG.	DEVICE
IC 2B	LF412
IC 5B	CD4555B

REFERENCE DESIGNATORS		
ITEM	LAST USED	NOT USED
C	24	13-20
CR	3	–
Q	24	11-20
IC	22	3, 12-20
R	76	15-21, 44-60

IC PWR & GND PINS			
DEVICE	+V	-V	GND
LF412	8	4	–
TL072	8	4	–
5532	8	4	–
4011BE	–	7	14
CD4069	–	7	14
CD4555	–	1,8,13 14,15	16

orban Orban Associates Inc.

TITLE: SCHEMATIC #8 CARD (OUTPUT) 60058-000-01

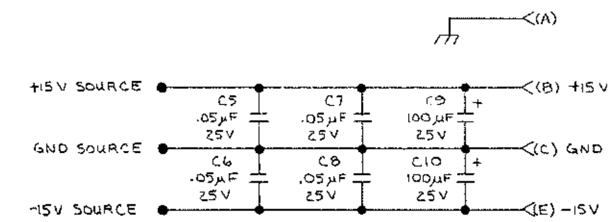
NOTES:

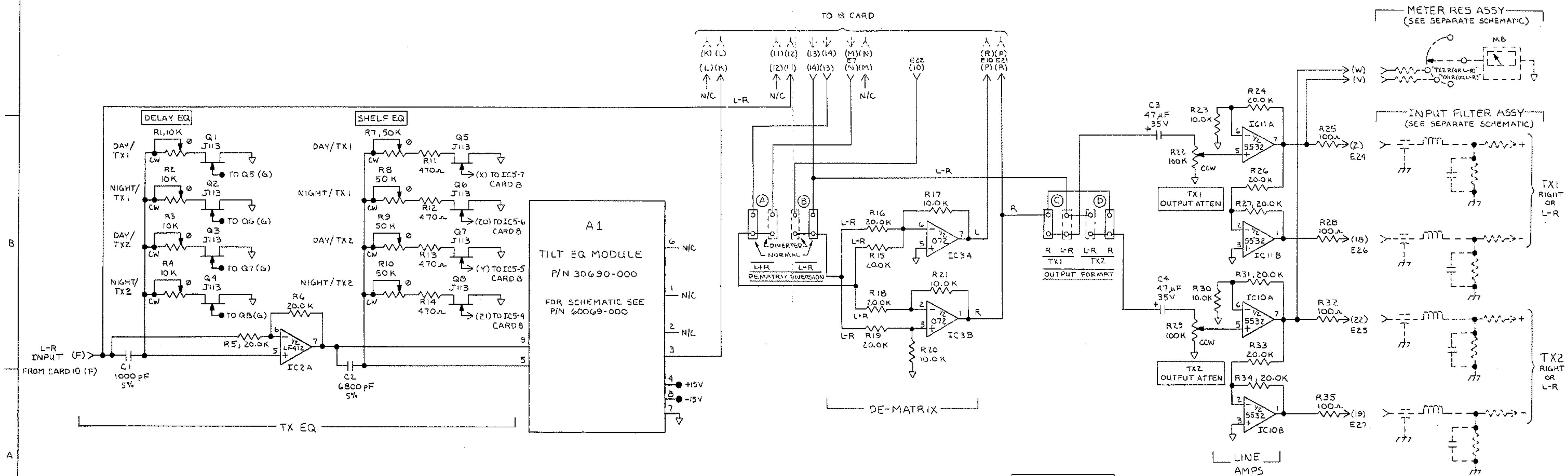
1. CARD #8 (SCH 60058) USES SAME PC FAB.

IC PWR & GND PINS			
DEVICE	+V	-V	GND
LF412	8	4	-
TL072	8	4	-
5532	8	4	-

UNUSED DEVICES	
REF. DES.	DEVICE
IC2B	LF412

REFERENCE DESIGNATORS		
ITEM	LAST USED	NOT USED
C	10	—
Q	8	—
IC	11	1, 4-9
R	35	—





NOTE

THIS CARD IS USED ON THE STEREO VERSION ONLY

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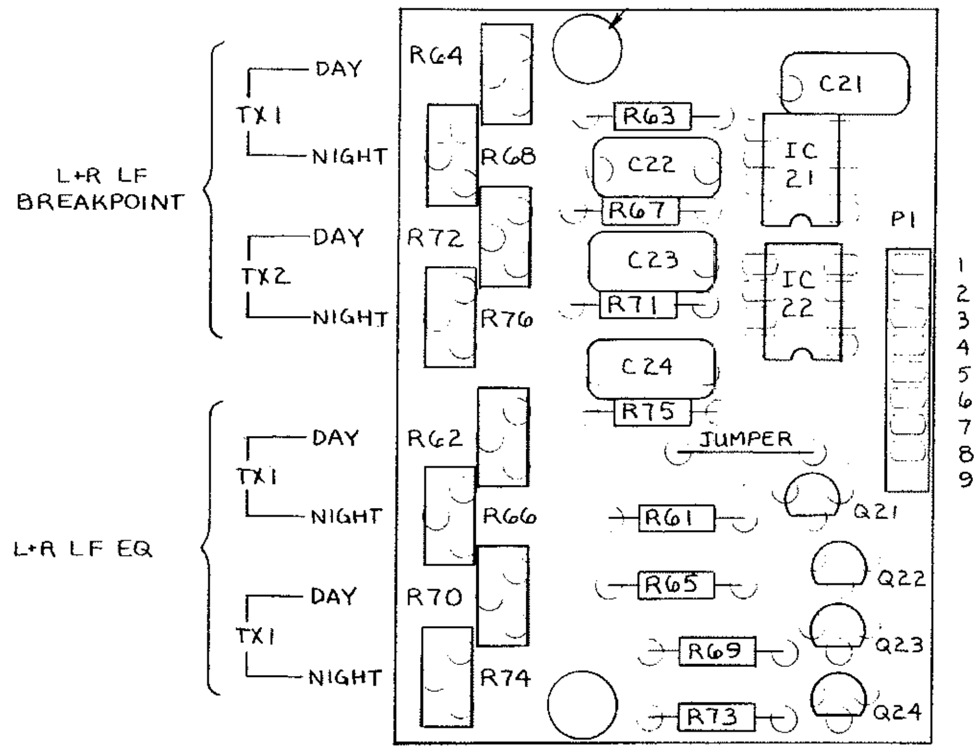
TITLE: SCHEMATIC
#9 CARD (OUTPUT)
60063-000-01



COMPONENT
SIDE

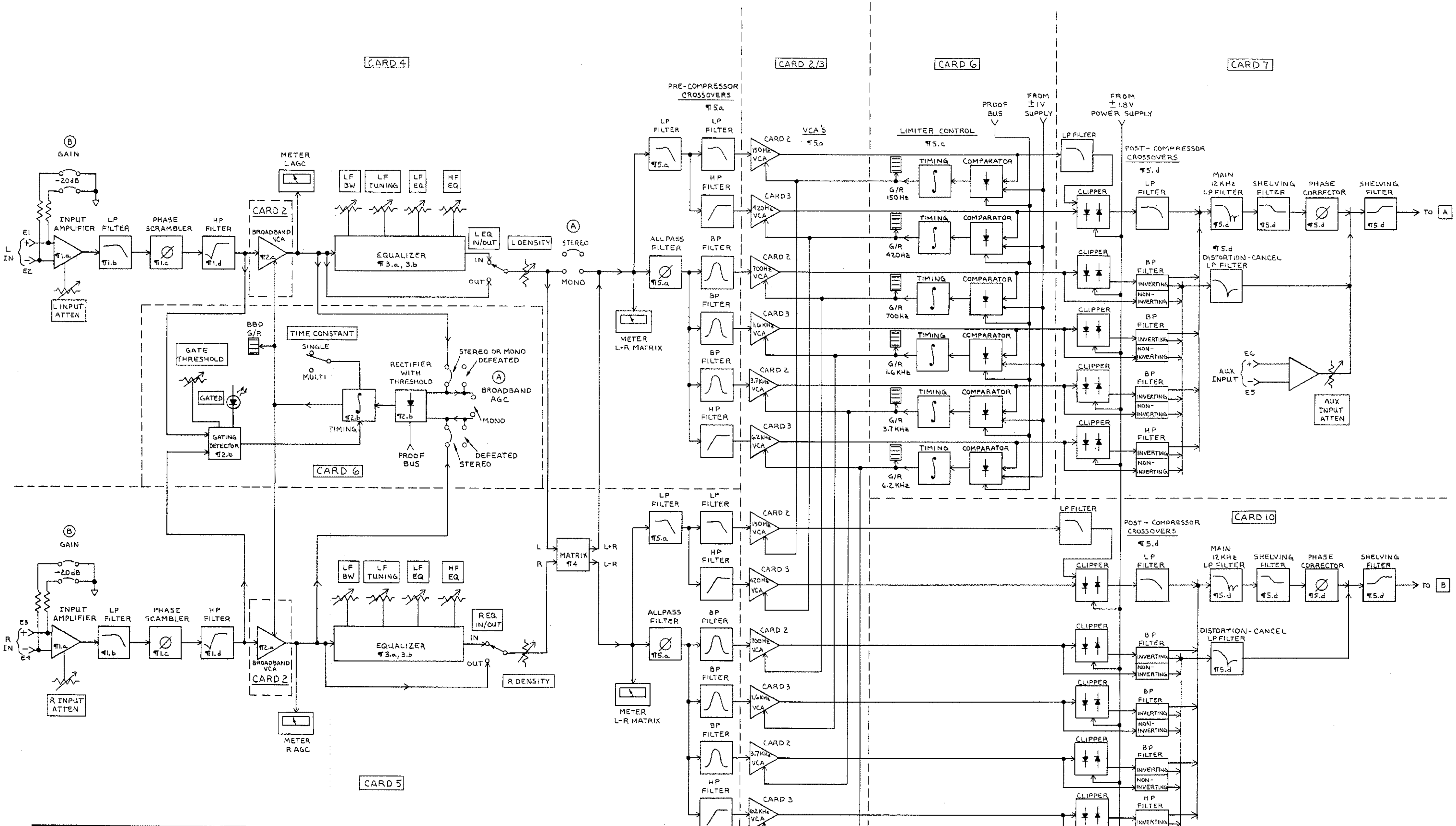
NOTES:

1. REF SCHEMATIC : 60058-VER
2. USED ON B CARD (30680-001) ONLY.

Orban Associates Inc.

TITLE: ASSEMBLY DRAWING
TILT EQ AUX
30685-000-01

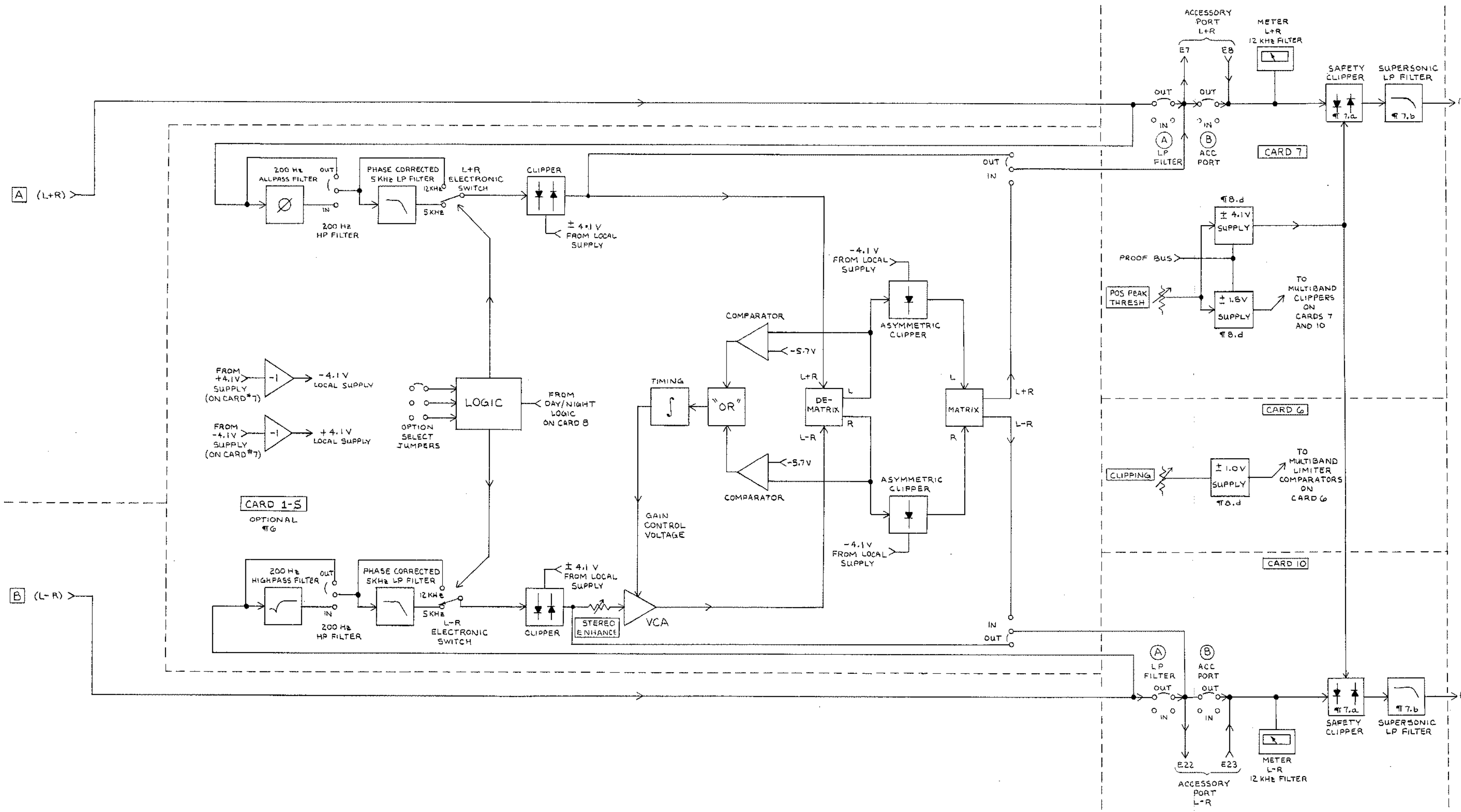
J



orban Orban Associates Inc.

TITLE: BLOCK DIAGRAM
PAGE 1 OF 3
60123-000-02

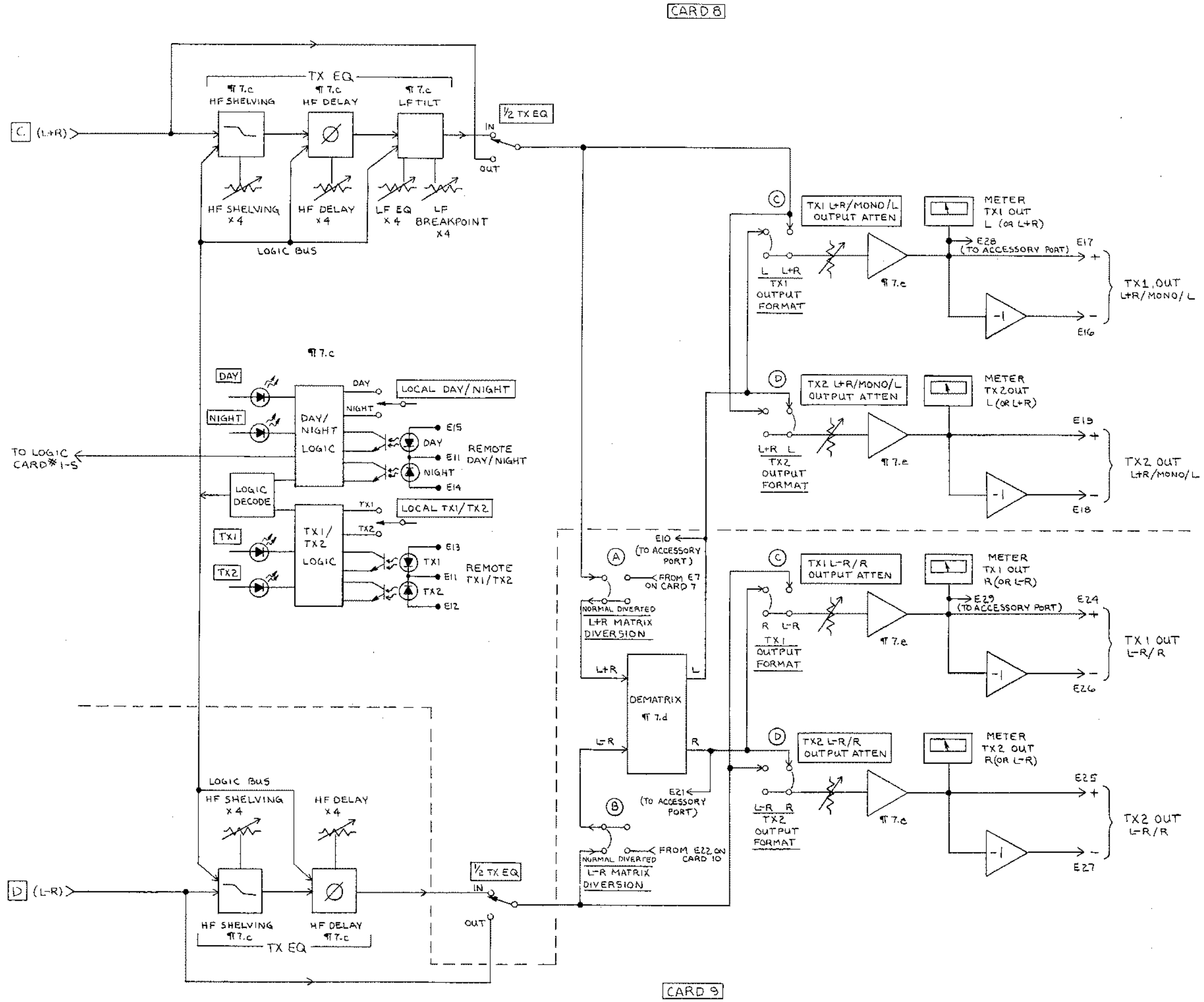
NOTES:
1. ¶ PARAGRAPH NUMBERS AND APPENDIX B (CIRCU
2. ∫ MEANS INTEGRATOR.
3. Ø MEANS PHASE SHIFTE!



J

Orban Associates Inc.

TITLE: BLOCK DIAGRAM
PAGE 2 OF 3
60123-000-02



orban

Orban Associates Inc.

TITLE: BLOCK DIAGRAM
PAGE 3 OF 3
60123-000-02

Parts List

Parts are listed by part class (such as "Resistors"), by assembly (such as "Card #5"), in Reference Designator order. Exceptions are certain widely-used common parts such as

Fixed Resistors
3/8" Square Trimmer Resistors
Signal Diodes

which are described generally. Such parts must be checked against the appropriate Schematic Diagram or physically examined to determine their exact value.

Obtaining Spare Parts

Because special or subtle characteristics of some components are exploited to produce an elegant design at reasonable cost, it is unwise to make substitutions for listed parts. It is also unwise to ignore notations in the Parts List indicating "Selected" or "Realignment Required" when replacing components. In such cases, the factory should be consulted to help you maintain optimum performance.

Orban ordinarily maintains an inventory of tested, exact-replacement spare parts to supply any present or normally-expected future demand quickly at a fair price.

If you order parts from the factory, please supply all of the following information:

-- The Orban Part Number, if you can determine it
-- The Reference Designator (like R6) for the part
-- A brief description of the part
-- And, from the Serial Label on the rear panel:
   - The exact Model Number (like 9100A/1)
   - The Serial Number
   - The "M" number, if any

Orban can supply standardized Spare Parts Kits for this product during its production life. Consult your dealer or the factory to obtain a list of the prices and contents of such kits.

To ease future maintenance, parts for this unit have been chosen from the catalogs of well-known manufacturers. Their U.S. headquarter addresses are listed at the end of the Parts List. Most manufacturers have extensive distribution facilities throughout the world and can often be contacted through local offices.

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS(1)	QUAN/ SYS.	NOTES
MODULES							
Card #4/5							
A1	Equalizer Module	30645-000-xx*					*Add suffix printed on part
Card #6							
A1-A3	Release Time Module	30665-001-xx*					*Add suffix printed on part
A4	Timing Module	30670-000-xx*					*Add suffix printed on part
Card #7/10							
A1	Distortion Cancel Filter	30490-002-xx*					*Add suffix printed on part
Card #8/9							
A1	Tilt Equalizer Module	30690-000-xx*					*Add suffix printed on part
CAPACITORS							
Chassis							
C1-21	Feedthrough, 1000pF	21118-210	ERE	2404-000 Series			
Power Supply and Regulator Board							
C101	Aluminum Electrolytic,40V,5000uF	21250-850	CD	5000-40-A2	Many		
C102	Same as C101						
C103	Ceramic Disc, 50V, .05uF	21107-350	CRL	UK50-503	Many		
C104	Same as C103						
C105	Feedthrough, 1000pF	21118-210	ERE	2404-000 Series			
C106	Same as C105						
C107	Same as C105						
C108	Tantalum, 10V, 33uF	21303-633	SPR	196D336X9010KA1	Many		
C109	Mica, 500V, 470pF, ±5%	21024-147	CD	CD19FD471J03	Many		
C110	Not used						
C111	Aluminum Electrolytic, 50V, 47uF	21208-647	SPR	502D476G050CD	Many		
C112	Same as C111						
C113	Mica, 500V, 100pF, ±5%	21020-110	CD	CD15FD101J03	Many		
C114	Polyester, 100V, .01uF, 10%	21401-310	SPR	225P10391WD3			
Input Filter Board							
C1-8	Ceramic Disc, 1000V,10%,.0015uF	21112-215	CRL	DD-152			

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 MODEL 9100A
Rev. 03 6/85
MODULES/CAPACITORS

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS(1)	QUAN/ SYS.	NOTES
CAPACITORS (cont)							
Card #1-S							
C1	Mica, 500V, 1%, 1000pF	21022-210	CD	CD19FD102F03		8	
C2	Mica, 500V, 1%, 150pF	21018-115	CD	CD15FD151F03		2	
C3-5	Same as C1						
C6	Polypropylene, 63V, 1%, .01uF	21701-310	WES	104/.01/F/68/B		11	
C7	Mica, 500V, 1%, 100pF	21018-110	CD	CD15FD101F03		2	
C8-10	Same as C6						
C11	Same as C1						
C12	Same as C2						
C13-15	Same as C1						
C16	Same as C6						
C17	Same as C7						
C18-22	Same as C6						
C23	Tantalum, 35V, 10%, .22uF	21307-422	SPR	196D224X9035HA1		1	
C24	Metallized Polyester, 100V, 5%, .047uF	21440-347	PLE	60C473J250		1	
C25	Mica, 500V, 5%, 470pF	21024-147	CD	CD19FD471J03		1	
C26	Same as C6						
C27	Aluminum, 25V, -20% +100%, 100uF	21206-710	PAN	ECE-A1EV101S		2	
C28	Ceramic, Monolythic, 50V, 20%, 0.1uF	21123-410	SPR	1C25Z5U104M050B		4	
C29	Same as C28						
C30	Same as C27						
C31,32	Same as C28						
Card #2/3							
C1	Mica, 5%, 150pF	21020-115	CD	CD15FD151J03			
C2	Mica, ±½pF, .5pF	21017-005	CD	CD15CD050D03			
C3	Metallized Polyester,100V,10%,0.1uF	21441-410	PLE	160-60C104J100			
C4	Mica, 1%, 100pF, 500V	21018-110	CD	CD15FD101F03			
C5	Mica, ±½pF, 10pF	21017-010	CD	CD15CD100D03			
C6	Same as C1						
C7	Same as C2						
C8	Same as C3						
C9	Same as C4						
C10	Same as C3						
C11-12	Same as C5						
C13	Same as C3						
C14	Same as C5						
C15	Same as C3						
C16-17	Same as C5						

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 MODEL 9100A
Rev. 03 6/85
CAPACITORS

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS(1)	QUAN/ SYS.	NOTES
CAPACITORS (cont)							
Card #2/3 (cont)							
C18	Same as C3						
C19	Same as C5						
C20	Same as C3						
C21-22	Same as C5						
C23	Same as C3						
C24	Same as C5						
C25	Polyester, 100V, 10%, .0022uF	21401-222	SPR	225P22291WD3			
C26-27	Ceramic Disc, 25V, 20%, .05uF	21123-410	SPR	1C25Z5U104M050B			
C28	Aluminum, radial, 25V, 100uF	21206-710	PAN	ECE-A1EV101S			
C29-30	Same as C26-27						
C31	Same as C28						
C32-33	Same as C2						
Card #4/5							
C1	Mica, 1%, 500V, 270pF	21018-127	CD	CD15FD271F03			
C2	Mica, 1%, 500V, 560pF	21022-156	CD	CD19FD561F03			
C3	Same as C1						
C4	Polycarb., 1%, .01uF	21601-310	ECI	652A1B103F			
C5-9	Polypropylene, 2%, 50V, .01uF	21702-310	NOB	CQ15P1H103GPP			
C10	Metallized Polyester, 5%, 100V, .47uF	21440-447	PLE	160-60F474J100			
C11-12	Metallized Polyester, 5%, 100V, 0.1uF	21440-410	PLE	160-60C104J100			
C13	Polypropylene, 1%, 50V, .01uF	21701-310	NOB	CQ15P1H103FPP			
C14-16	Mica, 1%, 500V, 1000pF	21022-210	CD	CD19FD102F03			
C17-18	Same as C5-9						
C19	Polycarb., 1%, 0.1uF	21601-410	ECI	652A1B104F			
C20	Aluminum, 63V, 33uF	21209-633	SPR	502D336G063CC1C			
C21-32	Same as C5-9						
C33-38	Same as C14-16						
C39-40	Aluminum, radial, 25V, 100uF	21206-710	PAN	ECE-A1EV101S			
C41-46	Ceramic, 20%, 25V, .05uF	21123-410	SPR	1C25Z5U104M050B			
Card #6							
C1-6	Ceramic Disc, 50V, 20%, .1uF	21123-410	SPR	1C25Z5U104M050B			
C7	Tantalum, 35V, 10%, 2.2uF	21307-522	SPR	196D225X9035JA1			
C8	Ceramic Disc, 1kV, 20%, .001uF	21112-210	CRL	DD-102			
C9	Tantalum, 35V, 10%, 1.0uF	21307-510	SPR	196D105X9035HA1			
C10	Metallized Polyester, 50V, 0.1uF	21441-410	PLE	160-60C104J100			
C11-12	Polyester, 100V, 10%, 0.1uF	21401-410	SPR	225P10491WD3			
C13-15	Aluminum, radial, 25V, 100uF	21206-710	PAN	ECE-A1EV101S			
C16-19	Same as C1-6						
C20-21	Same as C13-15						

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 MODEL 9100A
Rev. 03 6/85
CAPACITORS

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS(1)	QUAN/ SYS.	NOTES
CAPACITORS (cont)							
Card #7/10							
C1-3	Polypropylene, 1%, 50V, 0.0uF	21701-310	NOB	CQ15P1H103FPP			
C4	Polypropylene, 2%, 50V, .068uF	21702-368	NOB	CQ15P1H683GPP			
C5	Same as C1-3						
C6	Polypropylene, 2%, .0022uF	21702-222	NOB	CQ15P1H222GPP			
C7	Same as C1-3						
C8	Same as C4						
C9	Same as C6						
C10	Mica, 1%, 500V, 1000pF	21022-210	CD	CD19FD102F03			
C11	Same as C1-3						
C12	Same as C4						
C13-16	Same as C10						
C17	Mica, 1%, 500V, 160pF	21018-116	CD	CD15FD161F03			
C18	Mica, 1%, 500V, 100pF	21018-110	CD	CD15FD101F03			
C19-20	Same as C10						
C21	Mica, 1%, 500V, 560pF	21022-156	CD	CD19FD561F03			
C22	Mica, 1%, 500V, 2400pF	21022-224	CD	CD19FD242F03			
C23	Mica, 1%, 500V, 2700pF	21022-227	CD	CD19FD272F03			
C24-28	Same as C10						
C29	Not Used						
C30	Aluminum, 35V, 100uF	21207-710	SPR	502D107G035CG1C			
C31-32	Same as C10						
C33	Same as C18						
C34	Same as C10						
C35	Mica, 1%, 500V, 220pF	21020-122	CD	CD15FD221F03			
C36	Same as C1-3						
C37-38	Aluminum, 25V, 100uF	21206-710	PAN	ECE-A1EV101S			
C39-42	Ceramic, 20%, 25V, .05uF	21106-350	SPR	1C25Z5U104M050B			
Card #8/9							
C1	Mica, 1%, 500V, 1000pF	21022-210	CD	CD19FD102F03			
C2	Polystyrene, 2%, 50V, .0068uF	21504-268	SPR	287P6822R5A3			
C3-4	Aluminum, +100% -20%, 50V, 47uF	21208-647	SPR	502D476G050CD			
C5-8	Ceramic, 20%, 25V, .05uF	21123-410	SPR	1C25Z5U104M050B			
C9-10	Aluminum, 25V, 100uF	21206-710	PAN	ECE-A1EV101S			
C11-12	Polyester, 10%, 100V, .1uF	21441-410	WES	60C104J100			
Tilt EQ Auxiliary PCB (on Card #8)							
C21-24	Polyester, 10%, 100V, .1uF	21441-410	WES	60C104J100			

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

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS(1)	QUAN/ SYS.	NOTES
CAPACITORS (cont)							
	Monitor Rolloff Filter (Accessory)						
C1	Metallized Polyester, 5%, .034uF	21440-334	WES	60C104J100			
C2	Metallized Polycarbonate, 5%, .29uF	21603-429	ECI	652A1B294J			
DIODES							
ALL DIODES NOT OTHERWISE LISTED BY REFERENCE DESIGNATOR ARE:							
	Diode, Signal	22101-000	FSC	1N4148	Many		
	NOTE: This is a silicon small-signal diode, ultra fast recovery, high conductance. It may be replaced with 1N914 or, in Europe, with BAY 61. BV: 75V min. @ I_r = 5V I_r: 25nA max. @ V_r = 20V V_f: 1.0V max. @ I_f = 100 mA t_{rr}: 4ns max.						
	Card #6						
CR11	Diode, Zener, 9.1V, 10%	22003-091	MOT	1N4739			
	Card #7/10						
CR11-12	Diode, Signal	22102-001	HP	5082-2800			
CR14	Same as CR11-12						
	Power Supply and Regulator Board						
CR101-CR104	Diode, Rectifier, 400PIV, 3A	22203-400	MOT	MR504	Some		
CR105	Diode, Rectifier, 400PIV, 1A	22201-400	MOT	1N4004	Many		
CR106	Same as CR105						
	Meter Resistor Board						
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			
	Front Panel						
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			
	Card #1-S						
CR1	Diode, Signal	22102-001	HP	5082-2800		7	
CR2	Same as CR1						
CR3	Diode, Signal	22101-000	FSC	1N4148		6	
CR4,5	Same as CR3						
CR6,7	Same as CR1						
CR8-10	Same as CR3						
CR11-13	Same as CR1						

FOOTNOTES:

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SPECIFICATIONS AND SOURCES FOR REPLACEMENT PARTS
OPTIMOD-AM MODEL 9100A
Rev. 03 6/85
CAPACITORS/DIODES

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS(1)	QUAN/ SYS.	NOTES
INTEGRATED CIRCUITS							
	Power Supply and Regulator Board						
IC101	Regulator, Voltage	24301-502	TI	LM723CJ			
IC102	Single Opamp	24003-401	TI	LM301A	Many		
	Card #1-S (Optional Card)						
IC1	Linear, Dual Opamp, 072	24206-402	TI	TL072C		8	
IC2,3	Same as IC1						
IC4	Linear, Dual Opamp, 4558	24202-402	RAY	RC4558DE		1	
IC5	Same as IC1						
IC6	Linear, Single Opamp, 301A	24003-402	TI	LM301A		2	
IC7	Linear, Single Opamp, 5534	24014-402	SIG	NE5534FE		1	
IC8	Same as IC1						
IC9	Same as IC6						
IC10	Linear, Dual Opamp, 412	24209-202	NAT	LF412CN		1	
IC11	Same as IC1						
IC12	Digital, NAND Gate, 4011	24501-302	RCA	CD4011BE		1	
IC13,14	Same as IC1						
	Card #2/3						
IC1	Dual Opamp	24206-402	TI	TL072C			
IC2	Dual Opamp	24208-303	ORB	24208-303			(3)
IC3	Same as IC1						
IC4	Same as IC2						
IC5	Dual Opamp	24209-202	NAT	LF412			
IC6	Same as IC1						
IC7	Same as IC2						
IC8	Same as IC1						
IC9	Same as IC2						
IC10	Same as IC5						
IC11	Multi-Discrete	24402-302	RCA	CA3046			
IC12	Dual Opamp	24207-402	SIG	NE5532FE			
IC13	Same as IC2						
IC14	Same as IC12						
IC15	Same as IC2						
IC16	Same as IC1						
IC17	Single Opamp	24014-402	SIG	NE5534FE			
IC18	Same as IC2						
IC19	Same as IC17						
IC20	Same as IC1						
IC21	Same as IC5						

FOOTNOTES:

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SPECIFICATIONS AND SOURCES FOR REPLACEMENT PARTS
OPTIMOD-AM MODEL 9100A
Rev. 03 6/85
INTEGRATED CIRCUITS

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS(1)	QUAN/ SYS.	NOTES
INTEGRATED CIRCUITS (cont)							
	Card #4/5						
IC1-3	Dual Opamp	24206-402	TI	TL072C			
IC4	Single Opamp	24013-402	TI	TL071C			
IC5-8	Same as IC1-3						
IC9	Dual Opamp	24202-402	RAY	RC4558DE			
IC10-13	Same as IC1-3						
IC14	Dual Opamp	24207-402	SIG	NE5532			
	Card #6						
IC1-2	Comparator	24701-502	FSC	UA711DC			
IC3-4	Dual Opamp	24209-202	NAT	LF412			
IC5-6	Same as IC1-2						
IC7	Same as IC3-4						
IC8	Dual Opamp	24202-402	RAY	RC4558DE			
IC9-10	Same as IC1-2						
IC11	Same as IC3-4						
IC12	Same as IC8						
	Card #7/10						
IC1-6	Dual Opamp	24206-402	TI	TL072C			
IC7-8	Dual Opamp	24202-402	RAY	RC4558DE			
IC9	Same as IC1-6						
	Card #8/9						
IC1	Digital, Hex Inverter	24505-302	RCA	CD4069UBE			
IC2	Dual Opamp	24209-202	NAT	LF412			
IC3	Dual Opamp	24206-402	TI	TL072C			
IC4	Digital, NAND Gate	24501-302	RCA	CD4011BE			
IC5	Digital, Decoder	24506-302	RCA	CD4555BE			
IC6-9	Optoisolator	25003-000	LIT	SFH-601-1			
IC10-11	Dual Opamp	24207-402	SIG	NE5532			
	Tilt EQ Auxiliary PCB (on Card #8)						
IC21-22	Dual Opamp	24209-202	NAT	LF412			
INDUCTORS							
	Power Supply and Regulator Board						
L101	Inductor, 7uH	29501-004	OHM	Z-50	(2)		
L102	Same as L101						

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 MODEL 9100A
Rev. 03 6/85
INTEGRATED CIRCUITS/INDUCTORS

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS(1)	QUAN/ SYS.	NOTES
INDUCTORS (cont)							
	Input Filter Board						
L1-14	Inductor, 1.2mH	29503-000	MIL	73F123AF	(2)		
L15	Inductor, 7uH	29501-004	OHM	Z-50	(2)		
	Card #7/10						
L1-2	Inductor, Variable	29704-003	ORB				
L3	Inductor, Variable	29704-004	ORB				
	Monitor Rolloff Filter (Accessory)						
L1	Inductor, Variable	29703-002	ORB				
TRANSISTORS							
	Power Supply and Regulator Board						
Q101	Transistor, Power	23601-501	RCA	2N3055	Many		
Q102	Same as Q101						
Q103	Silicon, PNP	23002-101	FSC	2N4402	Many		
Q104	Same as Q103						
	Chassis						
Q101	Transistor, Power	23601-501	RCA	2N3055	Many		
Q102	Same as Q101						
	Card #1-S (Optional Card)						
Q1	Transistor, JFET/N, J113	23406-101	NAT	J113		4	
Q2-4	Same as Q1						
Q5	Transistor, JFET/N, J111	23403-101	NAT	J111		1	
	Card #2/3						
Q1-4	Transistor, PNP	23002-101	FSC	2N4402	Many		

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SPECIFICATIONS AND SOURCES FOR REPLACEMENT PARTS
OPTIMOD-AM MODEL 9100A
Rev. 03 6/85
INDUCTORS/TRANSISTORS

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS(1)	QUAN/ SYS.	NOTES
TRANSISTORS (cont)							
Card #6							
Q1	Transistor, Signal, NPN	23202-101	FSC	2N4400	Many		
Q2	Transistor, Signal, PNP	23002-101	FSC	2N4402	Many		
Q3	Same as Q1						
Q4	Same as Q2						
Q5	Same as Q1						
Q6	Same as Q2						
Q7	Same as Q1						
Q8	Same as Q2						
Q9	Same as Q1						
Q10	Same as Q2						
Q11	Same as Q1						
Q12	Same as Q2						
Q13	Transistor, J-FET, N-Channel	23406-101	NAT	J113			
Card #8/9							
Q1-8	Transistor, J-FET, N-Channel	23406-101	NAT	J113			
Q9-10	Transistor, Signal, NPN	23202-101	FSC	2N4400			
Tilt EQ Auxiliary PCB (on Card #8)							
Q21-24	Transistor, J-FET, N-Channel	23406-101	NAT	J113			

FOOTNOTES:

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

RESISTORS

ALL COMMON RESISTORS NOT LISTED ARE GENERALLY SPECIFIED BELOW.

Replace resistors only with the same style and with the exact value as marked on the resistor body, lest performance or stability be compromised. If the resistor is damaged, refer to the Schematic or consult the factory to obtain the value.

Metal Film Resistors

Body: conformally-coated
I.D.: five color bands or printed value
Orban P/N: 2004X-XXX
Power Rating: 1/8 Watt @ 70°C
Tolerance: 1%
Temperature Coefficient: 100 PPM/°C
U.S. Military Spec.: MIL-R-10509, Style RN55D
Manufacturers: R-Ohm (CRB-$\frac{1}{4}$FX), TRW/IRC, Beyschlag, Dale, Corning, Matsushita

Carbon Composition Resistors

Body: molded phenolic
I.D.: four color bands
Orban P/N: 2001X-XXX
Power Rating: (70°C) $\frac{1}{4}$ Watt (Body 0.090" x 0.250")
$\frac{1}{2}$ Watt (Body 0.140" x 0.375")
Tolerance: 5%
U.S. Military Spec.: MIL-R-11, Style RC-07 ($\frac{1}{4}$W) or RC-20 ($\frac{1}{2}$W)
Manufacturers: Allen-Bradley, TRW/IRC, Stackpole, Matsushita

Carbon Film Resistors

Body: conformally-coated
I.D.: four color bands
Orban P/N: 20001-XXX
Power Rating: $\frac{1}{4}$ Watt @ 70°C
Tolerance: 5%
Manufacturers: R-Ohm (R-25), Piher, Beyschlag, Dale, Phillips, Matsushita

Cermet Trimmer Resistors

Body: 3/8" square (9mm)
I.D.: printed marking on side
Orban P/N: 20509-XXX or 20510-XXX
Power Rating: $\frac{1}{2}$ Watt @ 70°C
Tolerance: 10%
Temperature Coefficient: 100 PPM/°C
Manufacturers: Beckman (72P or 72X series), Spectrol, Bourns, Matsushita

Power Supply and Regulator Board

R103	Wirewound, 2W, 0.62 OHM $\pm 5\%$	20028-862	IRC	BWF Series	(2)		
R104	Same as R103						
R106	Trimpot, 18 Turn, Cermet	20508-150	BEK	68XR500	Many		

Card #1-S (Optional Card)

R4	Resistor, Metal Film, 20.5K, $\pm 1/4\%$,	28521-008	ORB			5	
R8	Same as R4						
R18	Same as R4						
R25	Same as R4						
R29	Same as R4						
R85	Trimpot, 100 Ohm, 10%, 1T,	20520-110	BEK	82PA-Series		1	"Stereo Enhance"

Card #2/3

R4	Trimpot (Dip), QUAD, 100K	20530-001	BRN	7104D-410-104			
R32	Same as R4						
R61	Same as R4						
R89	Same as R4						

FOOTNOTES:

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SPECIFICATIONS AND SOURCES FOR REPLACEMENT PARTS
OPTIMOD-AM MODEL 9100A
Rev. 03 6/85
RESISTORS

J

REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS(1)	QUAN/ SYS.	NOTES
RESISTORS (cont)							
Card #4/5							
R7	Single Pot, 25K(5010R)	20742-000	CTS	270 Series	AB, BRN		
R35	Single Pot, 10K(LIN)	20720-000	CTS	270 Series	AB, BRN		
R36	Single Pot, 50K(5020R)	20724-000	CTS	270 Series	AB, BRN		
R43	Same as R35						
R46	Single Pot, 500K(5010R)	20746-000	CTS	270 Series	AB, BRN		
R49	Single Pot, 100K(5020)	20726-000	CTS	270 Series	AB, BRN		
Card #6							
R44	Single Pot, 100K(5020R)	20736-000	CTS	270 Series	AB, BRN		
R65	Single Pot, 10K(LIN)	20720-000	CTS	270 Series	AB, BRN		
Card #7/10							
R73	Single Pot, 100K(5020R)	20736-000	CTS	270 Series	AB, BRN		
R80	Single Pot, 10K(LIN)	20720-000	CTS	270 Series	AB, BRN		
Card #8/9							
R22	Trimpot, Cermet, 15T, 100K	20512-410	BEK	89PR100K	Many		
R29	Same as R22						
Monitor Rolloff Filter (Accessory)							
R4	Single Pot, 500 ohm (LIN)	20747-000	CTS	270 Series	AB, BRN		
SWITCHES							
Card #4/5							
S1	Switch, SPDT	26037-009	CK	7101SYA			
Card #6							
S1	Switch, DPDT	26037-010	CK	7201SYA			
S2	Switch, SPDT	26037-009	CK	7101SYA			
Card #8/9							
S1	Switch, DPDT	26037-010	CK	7201SYA			

FOOTNOTES:

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REF DES	DESCRIPTION	ORBAN P/N	VEN (1)	VENDOR P/N	ALTERNATE VENDORS (1)	QUAN/ SYS.	NOTES
SWITCHES (cont)							
Meter Resistor Board							
S1	Switch, Rotary, 1P12T NS	26078-306	CTS	212 Series	(2)		
Front Panel							
S2-3	Switch, SPDT(MOM)	26037-005	C&K	7105P3			
MISCELLANEOUS							
Chassis							
FL101	Filter, Line, 3A	28015-000	COR	3EF1	Many		UL/CSA/VDE
T1	Transformer, Power 38VCT 1A	55002-000					
	Connector, Card Edge, 22 Pos, Dual Readout	27041-010	TRW	50-44SN-1			
Power Supply and Regulator Board							
F101	Fuse, 3AG SLO-BLO, ½A	28005-001	LFE	313.500	BUS		For 115V MAINS (USE ¼A for 230V)
F102	Fuse, PICO 1A	28011-210	LFE	275001	BUS		
F103	Same as F102						
VR101	Diode, Zener, 5W, 16V ±5%	22005-160	MOT	1N5353B	Many		
VR102	Same as VR101						
Front Panel							
M1-7	Meter, Edge, 1mADC FS	28009-VER	EMI	Model 132D5			Custom Scale
M8	Meter, VU	28002-007	DIX	Model 330T			
Other							
	Extender PCB Assembly	30705-000					
	Line Cord, IEC	28102-002	BEL	17500	Many		

P/L REVISIONS:

30310-000-06	POWER SUPPLY	30720-000-01	CARD #1-S
30605-000-02	METER RESISTOR ASSY	30725-000-01	CARD #1-F
30620-000-02	INPUT FILTER ASSY	30625-VER-02	CARD #2/3
30650-000-01	MONITOR ROLLOFF FILTER BOARD	30640-VER-03	CARD #4/5
30685-000-01	TILT EQ AUXILIARY PCB	30660-000-02	CARD #6
40026-000-01	FRONT PANEL	30700-VER-02	CARD #7/10
40027-000-02	REAR PANEL	30680-VER-02	CARD #8/9

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SPECIFICATIONS AND SOURCES FOR REPLACEMENT PARTS
OPTIMOD-AM MODEL 9100A
Rev. 03 6/85
SWITCHES/MISCELLANEOUS

Vendor Codes

AB	Allen-Bradley Co. 1201 South Second St. Milwaukee, WI 53204
AD	Analog Devices, Inc. Route 1, Industrial Park P.O. Box 280 Norwood, MA 02062
AM	Amphenol North America An Allied Company 2122 York Road Oak Brook, IL 60521
BEK	Beckman Instruments, Inc. Helipot Division 2500 Harbor Blvd. Fullerton, CA 92634
BEL	Belden Corporation Electronic Division Richmond, IN 47374
BRN	Bourns, Inc. Trimpot Products Division 1200 Columbia Ave. Riverside, CA 92507
BUS	Bussmann Manufacturing Div. McGraw-Edison Company P. O. Box 14460 St. Louis, MO 63178
CD	Cornell-Dubilier Electronics 150 Avenue "L" Newark, NJ 07101
CK	C & K Components Inc. 15 Riverdale Avenue Newton, MA 02158
CRL	Centralab Inc. A North American Co. 5757 North Green Bay Ave. Milwaukee, WI 53201
COR	Corcom, Inc. 1600 Winchester Road Libertyville, IL 60048
CTS	CTS Corporation 905 N. West Blvd. Elkhart, IN 46514
ECI	Electrocube 1710 South Del Mar Avenue San Gabriel, CA 91776
ERE	Erie Technological Products, Inc. 644 West Twelfth Street Erie, PA 16512
EXR	Exar Integrated Systems, Inc. P. O. Box 62229 Sunnyvale, CA 94088
FSC	Fairchild Camera & Instr. Corp. 464 Ellis Street Mountain View, CA 94042
GI	General Instruments Optoelectronics Div. 3400 Hillview Ave. Palo Alto, CA 94304
HP	Hewlett-Packard Corporation 1501 Page Mill Road Palo Alto, CA 94304
INS	Intersil, Inc. 10710 N. Tantau Avenue Cupertino, CA 95014
IRC	TRW/IRC Resistors 401 North Broad Street Philadelphia, PA 19108
LFE	Littelfuse A Subsidiary of Tracor 800 East Northwest Highway Des Plaines, IL 60016
MAL	Mallory Timers Company Emhart Electrical/Electronic Group 3029 East Washington Street Indianapolis, IN 46206
MIL	J. W. Miller Division Bell Industries 19070 Reyes Avenue P. O. Box 5825 Compton, CA 90221
MOT	Motorola, Inc. P. O. Box 20912 Phoenix, AZ 85036
NAT	National Semiconductor Corp. 2900 Semiconductor Drive Santa Clara, CA 95051
NOB	Noble Teikoku Tsushin Kogyo Co. Ltd. 335, Kariyado, Nakahara-ku Kawasaki 211, JAPAN
OHM	Ohmite Manufacturing Company A North American Philips Co. 3601 Howard Street Skokie, IL 60076
ORB	Orban Associates Inc. 645 Bryant Street San Francisco, CA 94107
PAK	Paktron Div. of Illinois Tool Works Inc. 900 Follin Lane, S.E. Vienna, VA 22180
RAY	Raytheon Semiconductor Division 350 Ellis Street Mountain View, CA 94042
RCA	RCA Solid State Division Route 202 Somerville, NJ 08876
SCH	ITT Schadow, Inc. 8081 Wallace Road Eden Prairie, MN 55343
SIE	Siemens Components Division 186 Wood Avenue, South Iselin, NJ 08830
SIG	Signetics Corporation A Subsidiary of U.S. Philips Corp. P. O. Box 9052 Sunnyvale, CA 94086
SPR	Sprague Electric Company 125 Marshall Street North Adams, MA 01247
STK	Stackpole Components Company P. O. Box 14466 Raleigh, NC 27620
SYL	Sylvania Connector Prod. Oper. GTE Products Corporation Box 29 Titusville, PA 16354
TI	Texas Instruments P. O. Box 225012 Dallas, TX 75265
WES	Westlake 5334 Sterling Center Drive Westlake Village, CA 91361
WIM	WIMA P.O. Box 2345 Augusta-Anlage 56 D-6800 Mannheim 1 Germany

Appendix K:
Achieving High Source Quality

This **Appendix** has been adapted from a similar discussion originally written for FM. Surprisingly perhaps, subtle improvements in source quality can be far more audible on AM than you might imagine, given the fact that AM specifications often look so bad in comparison to FM specs.

Specs alone tell you little, particularly regarding something as subjective as the quality of highly-processed audio. One form of distortion often does not mask another, despite the fact that the various forms of distortion may all read the same on a meter. The human ear can be astonishingly perceptive, and is quite fussy about what it thinks sounds and feels good!

In addition, many forms of distortion which are quite subtle on the program line become highly exaggerated by "heavy" OPTIMOD-AM processing. This is why we have constantly emphasized the need for super-clean audio to get the most out of OPTIMOD-AM: audio quality far in excess of AM "business as usual".

So we hope that you'll approach the following with an open mind. Some of the suggestions may seem pretty far-fetched for AM! Yet superb audio quality can only be achieved by attention to detail. And the subjective audio quality achievable by OPTIMOD-AM, driving a first-class transmitter and antenna and driven by immaculate audio, may well amaze you -- even listened to through consumer equipment (such as a Delco car radio) of only moderate quality.

Achieving consistent state-of-the-art audio quality in AM broadcast is a very difficult task, requiring considerable skill, professionalism, and great dedication. But, as certain stations with stand-out audio have shown, it is possible!

DISK REPRODUCTION

Most radio programming still comes from phonograph records, either directly, or through tape dubs. We will address the problems of tape below; the current discussion centers on accurately retrieving as much information as possible from the grooves.

Disk is intrinsically a very high quality medium, and much effort has been expended by consumer manufacturers in developing audiophile cartridges, pickup arms, turntables, and phono preamps of highest quality. Unfortunately, much of this equipment is insufficiently mechanically rugged to withstand the pounding that it typically receives in day-to-day broadcast operations. At this writing, there are only two reasonably high quality cartridges made in the USA which are generally accepted to be sufficiently rugged to withstand professional use: the Stanton 681 series, and the Shure SC-39 series. Although rugged and reliable, neither produces the same cleanliness and transparency as the best audiophile cartridges. This phono cartridge dilemma is the prime argument for transferring all disk material to tape in the production studio, and playing only tape on the air. In this way, it is possible (with care) to use state-of-the-art cartridges, arms, and turntables in the dubbing process since requirements for mechanical ruggedness are relaxed. In addition, the problem of record wear is eliminated. However, maintaining tape equipment such that it causes no noticeable quality degradation is by no means easy, and the smaller station (particularly one without a full-time engineer) may well be able to achieve superior quality by playing disks directly on the air.

The following should be carefully considered when choosing and installing disk playback equipment.

1. The cartridge must be scrupulously aligned. When viewed from the front, the stylus must be absolutely perpendicular to the disc, or separation will suffer. The cartridge must be parallel to the headshell, or a fixed tracking error will be introduced. Overhang should be set as accurately as possible (± 1/16"), and vertical tracking angle should be set at 20 degrees (by adjusting arm height).

2. The tracking force must be correctly adjusted. Usually, better sound results from tracking close to the <u>maximum</u> force recommended by the cartridge manufacturer. If the cartridge has a built-in brush, don't forget to compensate for it by adding more tracking force according to manufacturer's recommendations.

3. Anti-skating force must be correctly adjusted. The accuracy of the anti-skating force calibration on many pickup arms is questionable. The best way to adjust anti-skating is to obtain a test record with an extremely high-level lateral cut (some IM test records are suitable). Connect the left channel output of the turntable preamp to the horizontal input of an oscilloscope, and the right channel preamp output to the vertical input. Operate the scope in the "X/Y" mode, such that a straight line is visible at a 45 degree angle. If the cartridge mistracks asymmetrically (indicating incorrect anti-skating compensation), then the scope trace will be "bent" at its ends. If this happens, adjust the anti-skating until the trace is a straight line, indicating symmetrical clipping.

   It is important to note that in live-disk operations, use of anti-skating may increase the incidence of the arm's sticking in damaged grooves instead of jumping over the bad spots. Increasing tracking force by approximately 15% has the same effect on distortion as applying antiskating, and in live-disk operations, the former expedient may be preferred.

4. A modern direct-drive turntable <u>must</u> be used. None of the older-design "professional broadcast" turntables have low enough rumble to be inaudible on the air. These old puck-, belt-, or gear-driven turntables might as well be thrown away! Multiband processing as used in OPTIMOD-AM can exaggerate rumble to extremely offensive levels.

5. Proper turntable mounting is crucial to avoid picking up footsteps or other building vibrations, and to avoid acoustic feedback from monitor speakers which will cause muddiness and severe loss of definition. The turntable is best mounted on a vibration isolator, which in turn is placed on a non-resonant pedestal mounted as solidly as possible to the building (preferably to a concrete slab).

6. Until recently, most "professional" phono preamps were seriously deficient compared to the best "audiophile" preamps. Fortunately, this situation has changed very recently, and a small number of high quality professional preamps are available (mostly from small manufacturers). A good preamp is characterized by extremely accurate RIAA equalization, high input overload point (better than 100mV @1kHz), low noise (optimized for the reactive source impedance of a real cartridge), low distortion (particularly CCIF difference-frequency IM), load resistance and capacitance adjustable for a given cartridge and cable capacitance, and effective RFI suppression.

After the preamp has been chosen and installed, the entire disk playback system should be checked with a reliable test record for compliance with the RIAA equalization curve. IF YOU WISH TO EQUALIZE THE STATION'S AIR SOUND TO PRODUCE A CERTAIN "SOUND SIGNATURE" ON THE AIR, THE PHONO PREAMP IS NOT THE PLACE TO DO IT. Some of the better preamps have adjustable equalizers to compensate for frequency response aberrations in phono cartridges. Since deviations of 0.5dB can be detected by critical listeners, ultra-accurate equalization of the entire cartridge/preamp system is most worthwhile.

The load capacitance and resistance should be adjusted according to the cartridge manufacturer's recommendations, taking into account the capacitance of the cables. If a separate equalizer control is not available, load capacitance and resistance may be trimmed to obtain flattest frequency response. Failure to do this can result in frequency response errors as great as 10dB in the 10-15kHz region!

The final step in adjusting the preamp is to accurately set the channel balance on the basis of a test record, and finally to set gain such that output clipping is avoided on any record. If you need to operate the preamp close to its maximum output level due to the system gain structure, then put a scope on the output of the preamp, and play a loud passage from an "audiophile" or "direct-to-disk" record. Set the gain so that at least 6dB peak headroom is left between the loudest part of the record and peak clipping in the preamp.

7. It is our opinion that the single most significant cause of distorted on-air sound is worn phono styli. Styli deteriorate sonically before any degradation at all is visible under a microscope because the cause of the degradation is usually deterioration of the mechanical damping and centering system in the stylus (or actual bending of the stylus shank) rather than diamond wear. This deterioration is primarily caused by back-cueing, although rough handling will always make a stylus die before its time.

   Styli used on-air in 24-hour service should be changed every two weeks as a matter of course -- damn the expense! D.J.'s and the engineering staff should listen constantly for audible deterioration of on-air quality, and should be particularly sensitive to distortion caused by defective styli. Such styli should immediately be replaced when problems are detected. One engineer we know immediately destroys old styli upon replacing them so that he is not tempted to keep a stock of old, deteriorated, but usable-looking styli!

   It is important to maintain a stock of new spare styli for such emergencies or for routine periodic replacement. There is no better example of false economy than waiting until styli fail before ordering new ones, or hanging onto worn-out styli until they literally collapse! Note also that smog- and smoke-laden air may seriously contaminate and damage shank mounting and damping material. Some care should be used to seal your stock of new styli to prevent such damage.

8. There are several impulse noise reduction systems currently available that effectively reduce the effects of "tics" and "pops" in disk reproduction without significantly veiling audio quality. They are particularly useful in live-disk operations where disks tend to become worn and damaged. The Burwen TNE-7000 is very effective in removing small "tics"; the SAE 5000 works well on larger scratches. Both devices can be connected in series at the output of the phono preamps to virtually elimininate the effects of disk damage. They must not be used elsewhere in the chain (such as in the program line) because the supersonic energy necessary to trigger their control circuitry will probably be rolled-off.

TAPE Despite its undeniable convenience, the tape cartridge (even at the current state-of-the-art) is still inferior to reel-to-reel in almost every performance aspect. Unlike the sometimes mystical sonic differences attributed to preamps and amplifiers, performance differences between cart and reel are readily measured, and include differences in frequency response, noise, high frequency headroom, wow and flutter, and particularly azimuth and interchannel phasing stability.

Sum-and-Difference Recording: Because it is vital in stereo AM broadcast to maintain mono compatibility, "sum and difference" recording is preferred in either reel or cart operations. This means that the mono sum signal (L+R) is recorded on one track, and the stereo difference signal (L-R) is recorded on the other track. A matrix circuit restores L and R upon playback. In this system, interchannel phase errors cause frequency-dependent stereo-field localization errors rather than deterioration of the frequency response of the mono sum.

Because this technique tends to degrade signal-to-noise (L+R usually dominates, forcing the L-R track to be under-recorded, thereby losing up to 6dB S/N), it is important to use a compander-type noise reduction system if sum-and-difference operation is employed.

Several manufacturers are currently selling electronic phase correction devices which are claimed to eliminate the effects of interchannel phase shifts. We have not evaluated any of these devices. However, if they work correctly, they might be a better solution than use of sum-and-difference recording.

Cheap Tape: Cheap tape, whether reel or cart, is a temptation to be avoided. Cheap tape may suffer from any (or all) of the following problems:

1. Sloppy slitting, causing the tape to weave across the heads, or, if too wide, to slowly cut away your tape guides;
2. Poor signal-to-noise ratio;
3. Poor high frequency response and/or high frequency headroom;
4. Inconsistency in sensitivity, bias requirements, or record EQ requirements from reel to reel, or even within a reel;
5. Splices within a reel;
6. Oxide shedding, causing severe tape machine cleaning and maintenance problems;
7. Squealing due to inadequate lubrication.

High-line name-brand tape is a good investment. It provides high initial quality, and guarantees that recordings will be resistant to wear and deterioration as they are played. Whatever your choice of tape, you should standardize on a single brand and type to assure consistency and to minimize tape machine alignment problems. Some of the most highly regarded tapes in current use (1982) include Agfa PEM468, Ampex 406, Ampex 456, BASF SPR-50 LHL, EMI 861, Fuji type FB, Maxell UD-XL, TDK GX, Scotch (3M) 206, Scotch 250, Scotch 226, and Sony SLH11.

It goes almost without saying that cheap carts are to be avoided like the plague, considering that even the best carts provide barely adequate quality. Since carts will interact with different transport designs in different ways, one of the best ways to choose a cartridge brand is to make extensive test on the cart machines you have in-house, and to choose the brand exhibiting the best interchannel phase stability and lowest wow and flutter with your particular machines.

Tape Speed: If all aspects of the disk-to-tape transfer receive scrupulous care, then the quality difference between 15ips (38cm/sec) and 7.5ips (19cm/sec) recording is easily audible. 15ips has far superior high frequency headroom. The effects of dropouts and tape irregularity are also reduced, and the effects of interchannel phase shifts are halved. In addition, a playback machine can deteriorate (due to oxide buildup on the heads or incorrect azimuth) far more severely at 15ips than at 7.5ips before an audible change occurs in audio quality.

Nevertheless, because of playback time limitations at 15ips, most stations operate at 7.5ips. (Many carts will not operate reliably at 15ips, and are subject to jamming and other problems.) This speed seems to be the lowest that is practical for use in day-to-day broadcast practice. While 3.75ips can produce good results under carefully controlled conditions, there are few operations which can keep playback machines well enough maintained to obtain consistent high quality 3.75ips playback day-in day-out. In addition, use of 3.75ips results in another jump in sensitivity to bad tape, high frequency saturation, and interchannel phase shifts.

Some are now promoting the use of cassettes as a serious broadcast program source. We feel that cassettes' low speed, tiny track width, sensitivity to dirt and tape defects, and severe high frequency headroom problems make such proposals totally impractical where consistent quality is demanded.

Use Of Noise Reduction: In order to reduce or avoid tape hiss, we recommend use of a compandor-type (encode/decode) noise reduction system in all tape operations. Dolby-B (TM Dolby Laboratories) is probably most suitable. Its 9dB noise reduction is quite sufficient to move tape hiss below the level of record surface noise if high-quality low-noise tape is used. In exchange for its modest amount of noise reduction, Dolby-B seems quite free of audible side-effects. (Dolby-A is even more effective, and is equally free of side-effects -- but it may strain your budget.)

Bear in mind that to achieve accurate Dolby tracking, record and playback levels must be matched better than 2dB. The Dolby tone should be faithfully recorded at the head of all reel-to-reel tapes, and level matching should be frequently checked. There should be no problem with level matching if tape machines are aligned weekly, as level standardization is part of this procedure. If a different type of tape is put in service, record machines must be immediately aligned to the new tape before any recordings are made.

In our opinion, all "single-ended" (i.e., dynamic noise filter) noise reduction systems cause totally unacceptable audible side-effects (principally program-dependent noise modulation) when used with music, and should never be used "on-line". They may have their place in the production studio, but even there they must be used extremely judiciously, with their operation constantly monitored by the station's "golden ears". Some possible applications include noise reduction of outside production work, and, when placed after the microphone preamp, reduction of ambient noise in the control room or production studio.

Tape Recorder Maintenance: Regular maintenance of magnetic tape recorders is of vital importance in achieving consistently high-quality sound. Maintenance of tape machines requires expertise and experience, and we can only lightly touch upon certain points.

1. Heads and guides should be cleaned every four hours of operation.

2. Tradition has it that machines should be demagnetized every eight hours. In our experience, magnetization is usually not a problem in playback-only machines in fixed locations. A magnetometer with a ±5 Gauss scale (R.B. Annis Co.,

Indianapolis, Indiana) should be used to periodically check for permanent magnetization of heads and guides. You will soon obtain experience on how long it takes for your machines in your environment to pick up enough permanent magnetization to be harmful. You may well find that this never happens with playback machines. (Record machines must be watched much more carefully.)

3. Deterioration of tape machine performance is usually gradual rather than catastrophic. It is therefore necessary to measure the performance of an on-air machine weekly with standard test tapes, and to take whatever corrective action is necessary if the machine is not meeting specifications. (Test tapes are manufactured by laboratories such as MRL, 229 Polaris Ave. #4, Mountain View, California 94043; and by STL, 26120 Eden Landing Rd. #5, Hayward, California 94545.)

4. Weekly maintenance should include measurement of flutter, using a flutter meter and high-quality test tape. Deterioration in flutter performance is often an early warning of impending mechanical failure. Spectrum analysis of the flutter can usually relate the flutter to a single rotating component. Deterioration in flutter performance can, at very least, indicate that adjustment of reel tension, capstan tension, reel alignment, or other mechanical parameter is required.

5. Weekly maintenance should also include measuring frequency response and interchannel phase shifts with a high-quality alignment tape. These measurements, which are expedited by the use of special swept-frequency or pink noise tapes available from some manufacturers (like MRL), provide an early indication of loss of correct head azimuth, or of head wear. (The swept tapes are used with an oscilloscope; the pink noise tapes with a third-octave real time analyzer.)

   If a head becomes worn, do not try to compensate by adjusting the playback equalizer. This will increase noise unacceptably, and will also introduce frequency response anomalies because the equalizer cannot accurately compensate for the shape of the rolloff caused by a worn head. Instead, the head must be replaced or lapped.

6. The reader should be particularly aware that alignment tapes wear out. With wear, the output at 15kHz may be reduced by several dB. If you have many tape machines to maintain, it is usually more economical to make your own "secondary standard" alignment tapes, and use these for weekly maintenance, while reserving your standard alignment tape for reference use.

   Do-it-yourself alignment tapes are best made with the traditional series of discrete tones. First align the playback section of the master recorder on which the home-made alignment tape is to be recorded, using a fresh standard alignment tape.

   Coarse Azimuth: First obtain a coarse adjustment by peaking the level of the 15kHz tone on the alignment tape, making sure that you have found the major peak. (There will be several minor peaks, many dB down. You will not encounter these unless the head is totally out of adjustment.)

   Reproduce Equalization: Run the alignment tape and adjust the reproduce equalizers for flat high frequency response, and for low frequency response which corresponds to the "fringing table" supplied with your alignment tape. The "fringing" effect appears below 500Hz, and will ordinarily result in an apparent bass boost of 2-3dB at 100Hz due to the fact that the alignment tape was recorded full-track and is being reproduced on a half-track head. (Fine azimuth adjustment won't work correctly if the playback equalizers are not set for identical frequency response, since non-identical frequency response will also result in non-identical phase response!)

Fine Azimuth: This adjustment is ideally made with a full-track mono pink noise tape and a real-time analyzer. If this instrumentation is available, sum the two channels together, connect the sum to the real-time analyzer, and adjust the azimuth for maximum high frequency response.

Other possibilities include observing the mono sum of a swept-frequency tape and maximizing its high frequency response, or aligning by ear by listening to the mono sum of the announcer's voice on the standard alignment tape, and adjusting for crispest sound. (The azimuth on the announcer's voice will be just as accurate as the rest of the tape.)

If the traditional Lissajous pattern is used, use several frequencies, and adjust for minimum differential phase at all frequencies. Using just one frequency (say 15kHz) can give totally erroneous results.

Calibration: After the azimuth has been carefully adjusted and the playback equalizer adjusted for maximally flat response from the standard alignment tape, write down the actual VU meter reading produced at each frequency on the spot-frequency standard alignment tape. Use the fringing table by subtracting the compensation from the readings you have just made. You will use the compensated readings below when you are recording your tape, since you are recording in half-track stereo instead of full-track mono.

Record Azimuth: Record your alignment tape using an audio oscillator. First, adjust the azimuth of the record head, by observing the mono sum from the playback head and exciting the record amplifier with pink noise, swept tones, or wide-range music (for "by-ear" adjustment). If you use a Lissajous pattern, be sure to use several frequencies as mentioned above.

Recording The Tape: You are then ready to record the spot frequencies on tape. Set the VU meter to "playback" and observe the reading as each tone is recorded. Adjust the tape recorder RECORD GAIN immediately after each frequency is switched until the VU meter reads the same as it did when you were playing the standard alignment tape. Your home-made tape should have an error of only 0.5dB or so if you follow these steps carefully.

REMEMBER THAT YOUR HOME-MADE TAPE WILL DETERIORATE WITH USE -- check it frequently against your "standard" reference tape.

The home-made tape is not suitable for critical azimuth adjustments. These should be made using the methods described above, employing a test tape recorded with a full-track head. Even if you happen to have an old full-track mono machine around, getting the azimuth exactly right is not practical, and a standard commercial alignment tape should be used for azimuth adjustments. Because ordinary wear does not affect the azimuth properties of the tape, it should have a very long life if properly stored.

ALL TEST TAPES SHOULD BE STORED "TAILS-OUT" (UNDER CONTROLLED TENSION) IN A TEMPERATURE AND HUMIDITY-CONTROLLED ENVIRONMENT. NEITHER EDGE OF THE TAPE PACK SHOULD TOUCH THE REEL FLANGES. This cannot be achieved unless the tape is wound onto the storage reel in normal PLAY mode, not in fast forward or rewind!

7. After the reproduce section of the tape machine is aligned, record alignment should be checked and adjusted as necessary. This involves setting record head azimuth, bias, equalization, and meter calibrations according to manufacturer's recommendations. We recommend that tape machines be adjusted so that +4dBm in and out corresponds to "0 VU" on the tape recorder's meter, and also to Dolby level and "Standard Operating Level". This is ordinarily 185 nW/m for "standard" tape and 250 nW/m for "high output" tape.

   Current practice calls for adjustment of bias by the "high-frequency overbias" method rather than by the "peak bias with 15 mil wavelength" method, as was formerly standard practice. Briefly, bias is adjusted by recording a 1 mil wavelength on tape (5Khz @7.5ips), and increasing bias until maximum output is produced from tape. Bias is then further increased until the output has decreased by a fixed amount -- usually 1.5 to 3dB. The correct amount of decrease is a function of both tape formulation and the width of the gap in the record head. The tape manufacturer's datasheet should be consulted.

8. In addition to the steps listed above, the manufacturer's recommendations should always be followed regarding maintenance. Most tape machines require periodic lubrication, and checking of reel holdback tensions and brake adjustments. With time, critical bearings will wear out in the motors and elsewhere. Failures here are usually indicated by incorrect speed, increased flutter, and/or audible increases in the mechanical noise made by the tape machine in operation. Use only lubricants and parts specified by the manufacturer.

9. Last, but by no means least -- KEEP IT CLEAN. Dust is a great destroyer of precision mechanical parts (and cigarette smoke is none too good, either). In addition to keeping dust away from the heads and guides, periodically clean the rest of the machine with a vacuum cleaner (suction mode, please!), or soft clean paint brush.

Cartridge Machine Maintenance: The general comments above apply to cart machines as well. However, these devices have their own set of idiosyncracies, largely because much of the tape guidance system is located in the cartridge, and is thus subject to the vagaries of the construction of the individual carts.

1. Because the lubricated tape deposits lubricant on pressure rollers and guides, frequent cleaning is advisable to assure lowest wow and flutter and to prevent possible cart jams. Cleaning should be performed as often as experience proves necessary. (Interestingly, because of the nature of the tape lubricant, it does not tend to deposit on head gaps and head cleaning is rarely required.).

2. Even with the best maintenance, interchannel phase shifts in conventionally-designed cart machines will usually prove troublesome. Check head alignment frequently. In addition, different brands of cart will show significant differences in phase stability in a given brand of machine. Run tests on various brands of cart, and standardize on the one offering best phase stability.

3. Because of the vast differences in design between manufacturers, it is difficult to provide much more specific advice. Precisely follow manufacturer's instructions regarding periodic maintenance, mechanical alignment, tensioning, lubrication, etc.

4. Many early (and some not-so-early) cart machine designs were saddled with completely inadequate electronics. Considerable improvement can be achieved in some of these machines by electronics modifications. Check electronics for record-amplifier headroom (be sure the amplifier can completely saturate the tape before it clips); record amplifier noise and equalization (some record amplifiers can actually contribute enough noise to dominate the overall noise performance of the machine); playback preamp noise and compliance with NAB equalization; power supply regulation, noise, and ripple; and line amplifier headroom. Check the alignment of the record level meter. (In order to improve apparent signal-to-noise ratio at the expense of distortion, some meters are calibrated so that "0" corresponds to significantly more than 1% third-harmonic distortion!)

   Probably the most universal problem is inadequate record amplifier headroom. In many cases, it is possible to improve the situation by increasing the operating current in the final record-head driver transistor close to its power dissipation limits. This is usually done by decreasing the value of emitter (and sometimes collector) resistors while observing the collector voltage to make sure that it stays at roughly half the power supply voltage under quiescent conditions, and adjusting the bias network as necessary if it doesn't.

SYSTEM CONSIDERATIONS

Headroom: Other than bad styli, the single most common cause of distorted air sound is probably clipping. The gain and overload point of every electronic component in the station must be critically reviewed to make sure that components are not being operated so that they introduce clipping distortion or excessive noise.

VU meters are worthless for checking peak levels. Even Peak Programme Meters are insufficiently fast to indicate clipping of momentary peaks, as their integration time is approximately 10ms. While the design of PPM's makes them excellent for monitoring operating levels in media with limited dynamic range (like magnetic tape) where small amounts of peak clipping are acceptable to achieve optimum signal-to-noise ratio, there is no excuse for any clipping at all in the purely electronic part of the signal path, since low noise and wide dynamic range are readily achieved with good design. For this reason, the peak levels should be monitored with a true peak-reading meter or with an oscilloscope, and gains adjusted so that peak clipping never occurs under any reasonable operating conditions (including sloppy D.J. gain riding!).

In the case of older equipment with very "soft" clipping characteristics, it may be impossible to see a well-defined clipping point on a scope. Or worse, audible distortion may occur many dB below the apparent clip point. In this case, the best thing to do is to determine the peak level producing 1% THD, and to arbitrarily call this level the clipping level. The scope can be calibrated to this 1% THD point, and headroom measurements can then be made.

The canny engineer will also be aware that certain system components (like microphone or phono preamps) have absolute input overload points. Difficulties often arise when gain controls are placed after early active stages, because the input stages can be overloaded without clipping the output. Many broadcast mike preamps are notorious for low input overload points, and can be easily clipped by high-output mikes and/or screaming D.J.'s. Similar problems can occur inside consoles if gain structures and operating points have been poorly chosen by the console designer, or if "Master" gain controls are operated with unusually large amounts of attenuation.

When operating with nominal line levels of +4 or +8dBm, the absolute clipping point of the line amplifier becomes critical. The headroom between nominal line level and the amplifier clipping point should be greater than 16dB. This implies that a line amplifier for a +4dBm line should clip at +20dBm or above, and that an amplifier for a +8dBm line should clip at +24dBm or above. In particular, it means that IC equipment (which almost always clips at +20dBm or so unless transformer-coupled) is not suited for use with +8dBm lines. +4dBm lines have become standard in the recording industry, and are preferred for all new studio construction (recording or broadcast) because of their compatibility with IC opamp operating levels.

The following components of a typical AM audio plant should be checked for operating level and headroom:

1. Phono preamps;
2. Tape and cart preamps;
3. Record amplifiers in tape machines;
4. Microphone preamps;
5. Console summing amplifiers;
6. Line amplifiers in consoles, tape recorders, etc.;
7. Distribution amplifiers (if used);
8. Signal processing devices such as equalizers;
9. Specialized communications devices, including remote broadcast links and telephone interface devices;
10. STL's, whether land-line or microwave.

Voice/Music Balance: The VU meter is very deceptive in indicating voice/music balance. The most artistically pleasing balance between voice and music usually results from peaking voice 4-6dB lower than music on the console VU meter. If heavy processing is being used, this factor may have to be increased further.

Following this practice will also help reduce the possibility of clipping voice (which is much more sensitive to clipping distortion than most music) in the electronics.

It is sometimes difficult to train operators to follow this practice. If the console has (or can be modified to have) separate summing amplifiers for live voice and music, then the correction factor is easily automated by building a separate summing amplifier (using a single IC opamp) to drive the VU meter, and summing the output of the voice summing amplifier into the VU amplifier with greater gain than the output of the music summing amplifier.

Electronic Quality: The AM medium is intrinsically prone to noise, and, because of spectrum allocations, fundamentally limited in bandwidth. AM is broadcast through transmitters whose noise and distortion perforance is significantly inferior to FM transmitters. Most important, the AM receivers in the hands of the public are of inferior quality and are likely to stay that way, since even high-quality AM cannot compete with FM quality except in automobiles (where FM tends to suffer from propogation problems). For these reasons, AM can never be a true high fidelity medium. The best one can hope for is to process in a such a way that the signal sounds pleasant, relatively wideband, and free from obvious fatigue-producing processing artifacts.

These limitations have considerable significance in gauging cost-effectiveness in current broadcast design practice. Most of the older-design broadcast electronic equipment (whether tube or transistor) is measurably and audibly inferior to properly-designed modern equipment. This is primarily due to a design philosophy which stressed ruggedness and RFI immunity over distortion and noise, and to the excessive use of inferior transformers. Frequency response was purposely rolled-off at the extremes of the audio range to make the equipment more RFI-immune. Cascading equipment of such design tends to increase both distortion and audible frequency response rolloffs to unacceptable levels.

Modern design practice emphasizes the use of high-slewrate, low-noise IC operational amplifiers such as the Signetics NE5534 family and the Texas Instruments TL070 family (both of which are used internally in the 8100A). While some designers insist that only discrete designs can provide ultimate quality, the performance of the best of the current IC's is so good that discrete designs are just not cost-effective for broadcast applications when the basic AM quality limitations are considered.

It has recently been discovered that capacitors have a subtle, but discernable effect upon sonic quality. Polar capacitors such as tantalums and aluminum electrolytics behave very differently from ideal capacitors. In particular, their very high dissipation factor and dielectric absorption can cause significant deterioration of complex musical waveforms. Ceramic capacitors have problems of similar severity. Polyester film capacitors can cause a similar, although less severe, effect when audio is passed through them.

For this reason, DC-coupling between stages (which is easy with opamps operated from dual positive and negative power supplies) is best. Coupling capacitors should be used only as absolutely necessary (to keep DC offsets out of faders, thus preventing "scratchiness", for example). If capacitors must be used, film types such as polystyrene, polypropylene, or polycarbonate are preferred.

If it is impractical to eliminate capacitors or to change capacitor types, don't be too concerned. It is probable that other quality-limiting factors will largely mask the capacitor-induced degradations, particularly in AM applications.

It goes almost without saying that the number of transformers in the audio path should be kept to an absolute minimum. Transformers are sometimes the only practical way to break ground loops and/or eliminate RFI. If a transformer is necessary, use a high-quality device like those designed by Deane Jensen and manufactured by Reichenbach Engineering, North Hollywood, California.

In summary, the path to highest quality is that which is closest to a straight wire. More is <u>not</u> better: every device removed from the audio path will yield an improvement in clarity, transparency, and fidelity. Use only the <u>minimum</u> number of amplifiers, capacitors, and transformers. Never leave, say, a line amplifier or compressor in "test" mode on line because it seems too much trouble to take it out. Small stations often sound dramatically superior on the air to their "big-time" rivals because the small station has a <u>simple</u> audio path, while the big-budget "big-timer" has thrown everything but the kitchen sink on line. The more equipment the station has (or can afford), the more restraint and self-discipline is required to keep the audio path simple and clean. Every amplifier, resistor, capacitor, transformer, switch contact, patch-bay contact, etc., is a potential source of audio degradation. Corrosion of patch-bay contacts and switches can be <u>particularly</u> troublesome, and the distortion caused by these problems is by no means subtle!

Any P.D. who boasts of his station's $20,000 worth of "enhancement" equipment should be first taken to a physician who can clean the wax from his ears, then forced to swear that he is not under the influence of any suspicious substances, and finally placed gently but firmly in front of a high-quality monitor system and shown exactly the sort of degradation that $20,000 worth of "enhancement" causes!

There is no situation where an old '70's cliche is more valid: Less <u>is</u> more.

PRODUCTION PRACTICES

General: The role of the production studio varies widely from station to station. If the production studio is used only for creation of spots, promos, ID's, etc., then quality requirements are considerably relaxed compared to a production studio in which programming is transferred from disk to tape or cart. Our discussion centers on the latter case.

Choosing The Monitor Loudspeakers: The production studio monitor system is the quality reference for all production work, and thus the air sound of the station. Considerable care in choice of equipment and its adjustment is necessary to assure a monitor sound which can be relied upon.

The loudspeakers are the single most important influence on quality. They should be chosen to complement room acoustics. In general, a production studio is fairly small, and "bookshelf"-sized speakers must be used because of space limitations.

It is desirable to assess the effect of equalization or other "sweetening" on small speakers to make sure that excessive bass or high-frequency boost has not been introduced. Such equalization errors can sound spectacular on big, wide-range speakers, while sounding terrible on small speakers with limited frequency response and power-handling capacity.

The recording industry has standardized on the Auratone Model 5C "Super Sound Cube" as a "small-speaker reference". We recommend that every production studio be equipped with a pair of these speakers, and that they be regularly used to assure the production operator that his work will sound good on small table and car radios.

The main loudspeakers should be chosen for high power-handling capacity, low distortion, high reliability and long-term stability, controlled dispersion (omnidirectional speakers are <u>not</u> recommended), good tone burst response at all frequencies, lack of cabinet diffraction, relatively flat axial <u>and</u> omnidirectional frequency response from 40-15,000Hz, and physical alignment of drivers such that if all drivers are excited simultaneously by an impulse, then the resulting waveforms arrive at the listener's ears simultaneously (sometimes called "time alignment").

Loudspeaker Location: The bass response of the speakers is strongly affected by their location in the room. Bass is weakest if the speaker is mounted in free air, away from any walls, and strongest when it is mounted in a corner. The corner location is to be avoided because it tends to excite standing waves, and the best location is probably against a wall at least 18" from any junction between walls. If the bass response is weak at this location because the speaker was designed for wall-junction mounting, it can be corrected by equalization (see below).

It is important that the loudspeakers be mounted so as to avoid acoustic feedback into the turntable, as this can produce a severe loss of definition and "muddy" sound.

Loudspeaker Equalization: The performance of any loudspeaker is <u>strongly</u> influenced by its mounting location and room acoustics. <u>Provided that room acoustics are good</u>, the third-octave real-time analyzer provides an extremely useful means of measuring any frequency response problems intrinsic to the loudspeaker, and of partially indicating problems due to loudspeaker placement and room acoustics.

By their nature, the third-octave measurements combine the effects of direct and reflected sound and may be misleading if room acoustics are unfavorable. Problems can include severe standing waves, reverberation time which is not well-behaved as a function of frequency, insufficient number of "normal modes" (Eigenmodes), lack of physical symmetry, and a number of other problems which, if discussed in adequate detail, would require a whole book!

There is a technique of measuring the loudspeaker/room interface called "Time-Delay Spectrometry"(TM) which provides much more information about acoustic problems than does the third-octave real-time analyzer. A certain number of sound contractors are now licensed to practice this technique. The technique is primarily used in "tuning" recording studio control rooms, and the cost may be prohibitive for a small or medium-sized station, particularly if measurements reveal that acoustics can only be improved by major modifications to the room.

Thus, the third-octave real-time analyzer is probably the best compromise for the typical radio station. If the station does not have a third-octave real-time analyzer and pink noise source, these can usually be rented from a local sound contractor or instrument rental house. To obtain meaningful results from the analyzer, the calibrated microphone which comes with the analyzer should be placed where the production engineer's ears would ordinarily be located. Each loudspeaker should be excited in turn with pink noise, and the acoustic response observed on the analyzer.

We recommend the Orban 674A dual-channel quasi-parametric equalizer as a monitor equalizer to "tune" the monitor system. The equalizer should be adjusted per manufacturer's instructions to obtain a real-time analyzer readout which is flat to 5kHz, and which rolls off at 3dB/octave thereafter. (A truly "flat" response is is not employed in typical loudspeakers, and will make most records sound unnaturally bright and noisy.)

If the two channels of the equalizer must be adjusted differently to obtain the desired response from the left and right channels, this indicates room acoustic problems or poorly-matched loudspeakers. The match is easy to check; just physically substitute one loudspeaker for the other, and see if the analyzer reads the same.

It is very revealing to move the microphone over a space of two feet or so while watching the analyzer to see how much the response changes. If the change is significant, then room acoustic problems or very poorly-controlled loudspeaker dispersion is indicated. In this case, you should measure the response at several positions and average. (There are devices called "microphone multiplexers" available to do this automatically. They require the use of several microphones, and they average the microphone outputs in a phase-insensitive way.)

Although it is permissible to adjust left and right equalizers differently below 200Hz, they should be set close to identically above 200Hz (to preserve stereo imaging), even if this results in less than ideal curves indicated on the third-octave analyzer. In this case, the limitations of this analysis technique (as described above) are coming into play.

Other Production Equipment: The general comments above on disk reproduction, tape, and electronic quality apply equally to the production studio. It is preferable to install "audiophile-quality" phono cartridges, arms, and turntables here, and to make sure that <u>one</u> person has responsibility for production quality and for making sure that the record playing equipment is not abused. The use of a single production director will also help achieve a consistent air sound, which is an important contribution to the "big-time" sound desired by many stations.

Although some people still swear by certain "classic" vacuum-tube power amplifiers (notably those manufactured by Marantz and McIntosh), the best choice for a monitor amplifier is probably a medium-power (100 watts/channel or so) solid-state amplifier with a good record of reliability in professional applications. Popular brands include Crown and BGW. (It may be tempting to dust off an old Gates or RCA power amplifier and place it in service as an economy measure. Don't. And don't use the monitor amplifiers built into your console, either!)

Production Practices: The following represents our opinions on production practices. We are aware that certain stations operate under substantially different philosophies. But we feel that the recommendations below are rational and offer the best hope of achieving consistently high quality.

1) Audio processing should not be applied in the production studio. The 9100A provides all the processing necessary with a remarkable lack of audible side-effects. Any further compression is not only undesirable but is likely to be very audible. If the production compressor has a slow attack time (producing overshoots which can activate gain reduction in the 9100A), it will probably "fight" with the 9100A, yielding air sound which is substantially worse than one might expect given the individual "sounds" of two units.

2) Substandard recordings may be "sweetened" with equalization to achieve tonal balance more typical of the best current product. However, excessive treble boost (to achieve a certain "sound signature" for the station) must be avoided if 7.5 ips tape is used because the tape is subject to high frequency saturation due to the high frequency boost applied by the recorder's equalization network. (The 9100A's HF Equalizer can provide all of the HF boost necessary to accurately equalize the rolloff of the average AM radio.) Substantially more freedom can be obtained by using an Orban 418A Compressor/Limiter/HF Limiter between the output of the production console and the input of the tape recorder or cart recorder. By adjusting the gain on the 418A such that broadband gain reduction never occurs when the console VU meters are peaking normally, only high frequency control will ordinarily occur, preventing high frequency tape saturation without adding unwanted broadband compression. However, the subtle broadband compressor will come into play to prevent tape overload if the console output level is peaked too high.

3) A compandor-type noise reduction system should be used on all taped material (see section on **TAPE**, above).

4) Even greater care than that employed in maintaining on-air equipment should be used in production studio maintenance since quality loss here will appear on the air again and again. The production director should be acutely sensitized to audible quality degradation and should immediately inform the engineering staff of any problems detected by ear.

5) Ideally, tape machines with noisy motors should be installed in alcoves under soffits, and there surrounded by acoustic treatment to prevent motor noise from leaking into the production microphone. In the real world of budget limitations, this is often not possible. Even in an untreated room, it is possible to use a directional microphone such as a figure-of-eight and to place the noisy machine on the "dead" axis of the microphone. Choosing the frequency response of the microphone to avoid exaggerating low frequencies will help. In particularly difficult cases, a noise gate or expander can be used after the microphone preamp to shut off the microphone except during actual speech.

6) Audio processing can be profitably applied to the microphone channel to give the sound more punch. Suitable equalization may include gentle low- and high-frequency boosts to "crispen" sound, aid intelligibility, and add a "big-time" quality to the announcer. (But beware using too much bass boost -- it can degrade intelligibility). Effects like telephone and transistor radio can be achieved with equalization, too. Orban manufactures a line of parametric equalizers (the 622A, 622B, 672A, and 674A) which are ideal for this work. The instruction manuals supplied with these units provide many hints on how to use them to achieve the effects often desired in broadcast production.

The punch of production material can often be enhanced by tasteful application of compression to the microphone chain. But avoid using an excessive amount of gain reduction and excessively fast release time, lest room noise and announcer breath sounds be exaggerated to grotesque levels. (This problem can be minimized if the compressor has a built-in expander or noise gate function.)

The close-miking customary in the production studio can exaggerate voice sibilance. In addition, many women's voices are sibilant enough to cause unpleasant effects. If high frequency equalization and/or compression are applied, sibilance will be further exaggerated.

The Orban 422A (mono) or 424A (stereo) gated compressor/limiter/de-esser provides a systems solution for all of these compression and de-essing requirements. It is useful not only on the mike channel but for general-purpose compression and limiting chores in the production studio as well.

If you prefer an uncompressed sound for production work but still have a sibilance problem, then a dedicated de-esser like the Orban 526A Dynamic Sibilance Controller located after all other processing in the microphone chain will prove most helpful.

SUMMARY

These comments only touch the surface of the techniques necessary to achieve audio quality comparable to the best FM operations or to a typical "high-end" home stereo system. Because of the built-in limitations of the AM medium, audio quality equal to that delivered by a well-operated FM station cannot be achieved, even if the signal entering the input terminals of the 9100A lives up to that quality level. However, this does not excuse sloppiness! The human ear is an astounding creation, and perceptive people are often amazed when they discover that they can detect rather subtle improvements in the basic audio chain through a Delco car radio! Nevertheless, a rational understanding of what quality can be achieved by the AM medium provides a useful guide to evaluating the cost-effectiveness of any equipment and/or techniques which are proposed to improve quality. In particular, it leads to the conclusion that today's high-quality IC opamps are ideally suited as amplification elements in broadcast. Compromises in disk playback and tape are far more likely to be audible on the air and extreme care must be used.

Maintaining a high level of on-air quality is a very difficult task, requiring constant dedication and cooperation between air talent and engineering. The 9100A provides a means of delivering audio to the AM listener's ear which is hifi-like in many aspects: a sense of openness, reasonably wide bandwidth, and freedom from distortion and processing artifacts are some of its more important attributes.

The 9100A will, however, tend to exaggerate flaws in the audio quality of the source. So following the suggestions in this **Appendix** can pay strong quality dividends which can be an important weapon in AM's battle against declining ratings.

The future belongs to the quality-conscious.

Appendix L:
Specifications

It is impossible to define the listening quality of even the simplest limiter or compressor on the basis of the usual specifications because such specifications cannot adequately describe the crucial *dynamic* processes which occur under program conditions. These dynamic processes are evaluated at the factory and controlled to close tolerances. The 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.

Certain specifications are therefore presented here to satisfy the engineer that they are reasonable, to help plan the installation, to help make certain comparisons with other processing equipment, and to verify that OPTIMOD-AM can readily pass a Proof of Performance. In order to facilitate this, all equalization can be switch-bypassed to enable a Proof to be performed under "flat" conditions as required by the FCC (U.S.A.).

INPUT

Impedance: Greater than 10 K ohms, electronically balanced by means of true instrumentation amplifier. RF suppressed.

Sensitivity: Normal operation may be achieved with nominal line levels of -30dBm or greater. Input sensitivity is controlled by means of INPUT ATTENUATOR control, and also by means of a bypassable 20dB pad before the input amplifier.

INPUT CONDITIONING FILTER

Highpass: -0.5dB @50Hz with rolloff exceeding 18dB/octave below that frequency. Includes deep 25Hz notch for automation cuetones.

Lowpass: Rolls off frequencies above 12kHz at rate exceeding 24dB/octave.

Allpass: Phase scrambler makes peaks more symmetrical to best utilize the capabilities of the processing.

BROADBAND COMPRESSOR

Range of Gain Reduction: 25dB

Compression Ratio: greater than 10:1

Time Constant Mode: SINGLE/MULTI, switch-selectable

Attack Time: approximately 200ms (SINGLE); program-controlled (MULTI)

Release Time: approximately 3dB/second (SINGLE), program-controlled (MULTI)

Total Harmonic Distortion: does not exceed 0.05% at any degree of gain reduction, 50-12,000Hz

Noise: greater than 85dB below output clipping level

Gating: gain will drift slowly to 10dB G/R if input level drops below a user-adjusted threshold

Variable-Gain Element: proprietary class-A VCA

PROGRAM EQUALIZER

Bass: "Quasi-Parametric" second-order peak boost equalizer. "Q" variable from 0.3 to 1.4. TUNING variable from 70 to 110Hz. EQ variable from 0 to +6dB.

High Frequency: Proprietary third-order shelving equalizer (patent pending) matches inverse of "average" (see text) receiver rolloff to a high frequency limit, adjustable from no equalization at all, through any frequency up to 6kHz.

Noise and Distortion are substantially below other elements in the system.

SIX-BAND LIMITER

Filters: 150Hz lowpass; 420Hz bandpass; 700Hz bandpass; 1.6kHz bandpass; 3.7kHz bandpass; 6.2kHz highpass.

Filter Selectivity: 18dB/octave

Filter Topology: parallel.

Filter Combination:

Static: outputs of all filters combine to yield static frequency response ±0.5dB throughout the range of 50-12,000Hz.

Dynamic: Phase interaction between filters under program conditions will not cause audible dips in the frequency response.

Limiters:

Range of Gain Reduction: 25dB.

Attack Time: program controlled; adjusted according to band frequency.

Release Time: program controlled; adjusted according to band frequency.

Total Harmonic Distortion (each limiter): does not exceed 0.1% for any frequency in each limiter's passband with any degree of gain reduction, provided signal is below multiband clipper threshold.

Distortion Cancellation: all clipper-induced distortion in upper four bands cancelled better than 30dB below 1.8kHz. Additional distortion reduction provided as function of frequency in each band.

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

Variable-Gain Elements: proprietary class-A VCA's.

OUTPUT FILTER

Filter Characteristics: 12kHz 5th order elliptical is standard. System guaranteed to meet all requirements of FCC 73.40.a.12 regarding occupied bandwidth for arbitrary adjustments of processing controls and arbitrary program material, provided that the transmitter does not add significant high-frequency harmonic distortion to its spectrum.

Optional Filters: Optional plug-in card contains two phase-corrected 5kHz 30dB/octave filters (for L + R and L − R processing). Also contains a delay network which can be inserted in the L + R path to match the delay of the L − R 5kHz filter if 5kHz bandwidth limitation is desired in the L − R path only. Filters are coupled to the system DAY/NIGHT logic. The card may be strapped in any one of four configurations.

	DAY		NIGHT	
OPTIONS	L+R	L−R	L+R	L−R
1	12kHz	12kHz	5kHz	5kHz
2	12kHz	5kHz	5kHz	5kHz
3	12kHz	5kHz	12kHz	5kHz
4	5kHz	5kHz	5kHz	5kHz

TRANSMITTER EQUALIZER

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-technology transmitters. Independent control of very-low-frequency compensation available to avoid 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's" in transmitters, phasors, and/or antenna systems, or due to poor transient response in audio or modulator stages.

High Frequency Delay Equalizer: Introduces added time delay selectively into the spectrum to compensate for non-linear group delay in the transmitter/antenna system, thru optimizing transient response by creating approximately constant time delay at all frequencies within the audio bandwidth.

Controls: Four separate sets of controls are provided which can be independently adjusted for DAY/TX1, DAY/TX2, NIGHT/TX1, and NIGHT/TX2, and can be remotely switched by momentary application of 6-24V AC/DC between the appropriate terminals on the rear-panel barrier strip. Day/Night and TX1/TX2 status is indicated by pairs of LED's on the front panel. A test point is located behind the control access door. Either a sinewave or squarewave oscillator may be used to drive this test point for TX equalizer alignment.

LINE DRIVER

Output Impedance: 290 ohms, electronically-balanced to ground. RF suppressed by means of third-order non-overshooting EMI filter.

Output Level: will drive greater than +20dBm into 600 ohms.

Configuration (mono): Outputs for two transmitters, each with independent TX EQ and 18-turn screwdriver-adjust OUTPUT ATTENUATOR controls.

Configuration (stereo): Outputs for two transmitters (each transmitter having its own stereo generator), each output with independent TX EQ and 18-turn screwdriver-adjust OUTPUT ATTENUATOR control. Outputs can be strapped for L & R, or L + R and L − R depending on the needs of the subsequent stereo generator.

COMPLETE SYSTEM (PROOF MODE)

(Note: PROOF mode requires that all control circuitry for compression and limiting be defeated, and that the program equalizer and TX equalizer be switched OUT, leaving all active circuitry other than the equalizers in-line.)

Frequency Response: better than ±1.0dB, 50-7500Hz (optional 5kHz filters defeated).

Total Harmonic Distortion: less than 0.2% at 100% modulation, 50-7500Hz.

RMS Noise: better than 65dB below 100% modulation, 30-20,000Hz.

Stereo Separation: better than 25dB, 50-10,000Hz; typically 35dB

PHYSICAL

Dimensions: 19"W x 7"H x 12.5"D (4 EIA rack units); (48.3cm x 17.8cm x 31.8cm).

Shipping Weight: 27 lbs. (12 Kg.) Net; 38 lbs. (17 Kg.) Gross

Operating Temperature: 0-50 degrees C (32-122 degrees F).

EMI Environment: Circuitry shielded against EMI from 500kHz - 1 GHz.

Access: Circuitry (except for power supply regulator) on plug-in cards. All circuitry and user setup adjustments available from front panel without removing unit from rack. Control access door is fitted with a lock to prevent unauthorized adjustments.

Power Requirements: 115/230V AC ±15%, 50/60 Hz.

Maximum AC Leakage to Chassis: 0.25mA @115VAC; 0.5mA @230VAC.

WARRANTY

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