BEFORE PROCEEDING WITH COMPLETE UNPACKING AND SETUP
PLEASE READ THE SECTION ON UNPACKING AND INSPECTION

model 539
ROOM EQUALIZER



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SECTION I

INTRODUCTION

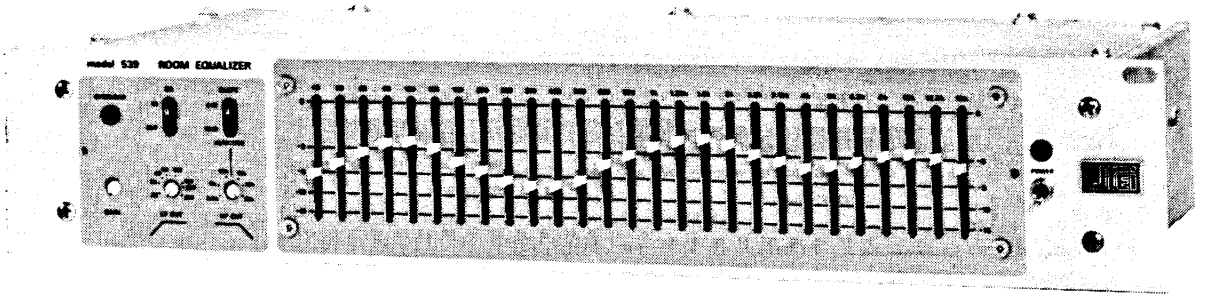


FIGURE 1. MODEL 539 FRONT PANEL.

1.1 DESCRIPTION.

The Model 539 is a 1/3-octave Equalizer which was designed specifically for room equalization. It is an ideal tool for corrective equalization in professional sound recording, sound reinforcement systems, broadcast, motion picture and TV recording, and live performances.

Twenty seven controls provide continuous attenuation of 15 dB at each of the 1/3-ocatve frequency bands, centered from 40 Hz to 16 kHz. In addition, High Cut and Low Cut filter sections are included to adjust the Model 539's overall bandwidth. The cutoff filters are of the Butterworth type with an attenuation of 12 dB/octave for the L.F. filter and a switch-selectable 12 dB or 6 dB/octave for the H.F. filter beyond their -3 dB points. The tuning range of the Low Cut filter is from 20 Hz to 250 Hz, and the High Cut filter from 3.5 kHz to 20 kHz.

The 27 band-reject filters are active, minimum phase L-C networks, whose skirts combine smoothly for minimum ripple and phase shift. An adjustable front panel gain control provides up to 20 dB gain to make up attenuation of the filters and to establish maximum gain before feedback for the equalized system. A bypass switch permits switching the filter out of the system and restoring unity gain.

An overload detection circuit monitors the signal at the input and output. If the signal level approaches overload, a front panel LED flashes to warn the user.

NOTE: Throughout this manual, where the expression "dB" is used to denote a signal level, it is referenced to 0 dB = 0.775 volts rms.

An optional accessory Model SC-1 Security Cover may be installed over the front panel to protect all operating controls against inadvertent disturbance or tampering in fixed installations. Also available is a set of 27 push-on knobs, Knob Set 539 K, helpful when frequent adjustment of the controls is necessary.

1.2 SPECIFICATIONS

ELECTRICAL:

INPUT:	Balanced bridging, differential amplifier.
INPUT IMPEDANCE:	40 kohms, used as balanced input. 20 kohms, used as unbalanced (single-ended) input.
MAXIMUM INPUT LEVEL:	+20 dB (7.75 V rms).
EQUIVALENT INPUT NOISE:	Less than -90 dBm (15.7 kHz bandwidth) with all controls set flat, output terminated with 600 ohm load.
GAIN:	EQ out - unity, ±1 dB, EQ in - from unity to +20dB.
FREQUENCY RESPONSE:	±1 dB, 20-20,000 Hz (EQ out), +1dB, -3dB, 20-20,000 Hz (EQ in).
OUTPUT:	Floating, transformer isolated.
OUTPUT LOAD:	150 ohms or greater.
POWER OUTPUT:	+24 dBm into 600 ohm load. (12.28 Volts) +26 dB into 150 ohm load. (7.75 Volts)
DISTORTION:	Less than 0.5% THD, 30 Hz to 15 kHz at maximum rated output.
POWER REQUIREMENTS:	100-125 VAC or 200-250 VAC, 50/60 Hz, switch selectable, less than 10 W.
ENVIRONMENT:	Operating 0°C to +50°C (+32°F to +122°F); storage -20°C to +60°C (-4°F to +140°F).

FILTER CHARACTERISTICS:

GRAPHIC SECTION:	27 individual 1/3-octave L-C type active filters (1/3-octave at -3dB points with 8 dB cut).

CENTER FREQUENCIES:	Standard ISO (Hz) 40 50 63 80 125 160 200 250 315 400 500 630 800 1K 1.25K 1.6K 2K 2.5K 3.15K 4K 5K 6.3K 8K 10K 12.5K 16K.
FREQUENCY ACCURACY:	±3% of center frequency.
ATTENUATION RANGE:	0 to -15 dB (single filter section).
ATTENUATION CALIBRATION:	Within 1 dB of indicated setting, 0 to -5 dB, Within 1.5 dB of indicated setting, -5 to -15 dB (single filter section).
BAND LIMIT FILTERS:	Low Cut -12 dB/octave, Butterworth, -3 dB point continuously adjustable from 20 Hz to 250 Hz. High Cut -6 dB or -12 dB/octave, switch-selectable, Butterworth, -3 dB point continuously adjustable from 3.5 kHz to 20 kHz.

PHYSICAL:

DIMENSIONS:	483 x 89 mm rack panel; Depth behind panel 203 mm. (19" x 3-1/2" x 8")
FINISH:	Panel is 3.18 mm (1/8") brushed clear anodized aluminum. Chassis is cadmium plated steel.
WEIGHT:	5.00 kg (11 pounds).
SHIPPING WEIGHT:	7.23 kg (16 pounds).
ACCESSORIES:	Model SC-1 Security Cover, smoke gray transparent plastic; covers all operating controls. Knob Set 539 K.

1.3 CONTROLS

EQUALIZATION:	27 vertical slide controls, continuously variable 0 to -15 dB.
L.F. CUT:	Screwdriver adjustable, 20 Hz to 250 Hz.
H.F. CUT:	Screwdriver adjustable, 3.5 kHz to 20 kHz.
H.F. SLOPE:	Toggle switch selects 6 dB or 12 dB/octave below -3 dB point.

GAIN:	Screwdriver adjustable from unity to +20 dB (EQ in).
EQ IN/OUT:	Front panel toggle switch.
POWER:	Front panel toggle switch.
MAINS VOLTAGE:	Rear panel slide switch, 115/230 volt.
INDICATORS:	LED, power ON. LED, overload condition, level monitored at input and output.

1.4 CONNECTIONS

All connections for input and output are made through a barrier strip at the rear of the chassis. (See Installation Instructions, Section 2.5, Figures 2 and 3.)

SECTION II

INSPECTION AND INSTALLATION

2.1 UNPACKING AND INSPECTION

Your Model 539 was carefully packed at the factory, and the container was designed to protect the unit from rough handling. Nevertheless, we recommend careful examination of the shipping carton and its contents for any sign of physical damage which could have occurred in transit.

If damage is evident, do not destroy any of the packing material or the carton, and immediately notify the carrier of a possible claim for damage. Shipping claims must be made by the consignee.

The shipment should include:

Model 539 Room Equalizer

UREI Instruction Manual (this book)

Two-part Warranty Card bearing the same serial number as the Model 539.

Rack Mounting Hardware

2.2 ENVIRONMENTAL CONSIDERATIONS

The system will operate satisfactorily over a range of ambient temperatures from 0°C to +50°C (+32°F to 122°F), and up to 80% relative humidity.

If the system is installed in an equipment rack together with high heat producing equipment (such as power amplifiers), adequate ventilation should be provided to prolong the life of components. Also, while circuitry susceptible to hum pick-up is sufficiently shielded from moderate electromagnetic fields, installation should be planned to avoid mounting the system immediately adjacent to large power transformers, motors, etc.

2.3 POWERING

The 539 may be operated from either 100-125 VAC or 200-250 VAC mains (50 or 60 Hz, single phase.) As indicated in section 2.4, the nominal line voltage may be selected with a rear panel switch. BE SURE TO VERIFY BOTH THE ACTUAL LINE VOLTAGE, AND THE SETTING OF THE VOLTAGE SELECTOR SWITCH BEFORE CONNECTING THE 539 TO THE MAINS.

To comply with most Electrical Codes, the 539 is supplied with a three-wire AC cord, the grounding pin of which is connected to the chassis. In some installations this may create ground-loop

problems. Ground loops can become very evident (as hum and buzz) if a significant potential difference exists between the AC conduit ground and the grounded metal enclosure in which the chassis is installed. If hum is experienced, check for the possibility of ground loops by using a 3-prong to 2-prong AC adapter, ungrounding the AC plug temporarily. This ungrounds the Model 539, and will probably cure the hum or buzz, but is not a substitute for proper system grounding. Be aware that unless the Model 539 Room equalizer is AC grounded, a safety hazard can exist. UREI accepts no responsibility for legal actions or for direct, incidental or consequential damages that may result from violation of any electrical codes.

2.4 LINE VOLTAGE SWITCH

Unless a tag on the line cord specifies otherwise, the Model 539 was shipped ready for operation with nominal 115 VAC power mains. In order to change this for nominal 230 V (50 or 60 Hz), slide the VOLTAGE SELECTOR switch on the rear panel to the 230 position. The voltage is visible in a window next to the switch slot. Be sure to change the fuse to the correct value: 1/8-amp slo-blo when changing to 230 V operation or 1/4-amp slo-blo for 115 V operation. A small screwdriver should be used to move the recessed switch.

2.5 EXTERNAL CONNECTIONS

Permanent input and output signal wires should be shielded cable, and connected in accordance with standard wiring practice, as indicated on the rear panel barrier strip.

If the Model 539 output is connected to a high impedance circuit, we recommend shunting the "±" and "COM" output terminals with a 620 ohm, 1/2 watt resistor. This assures optimum loading of the output stage. (See section 2.6 regarding input termination).

(See Figures 2 & 3, next page)

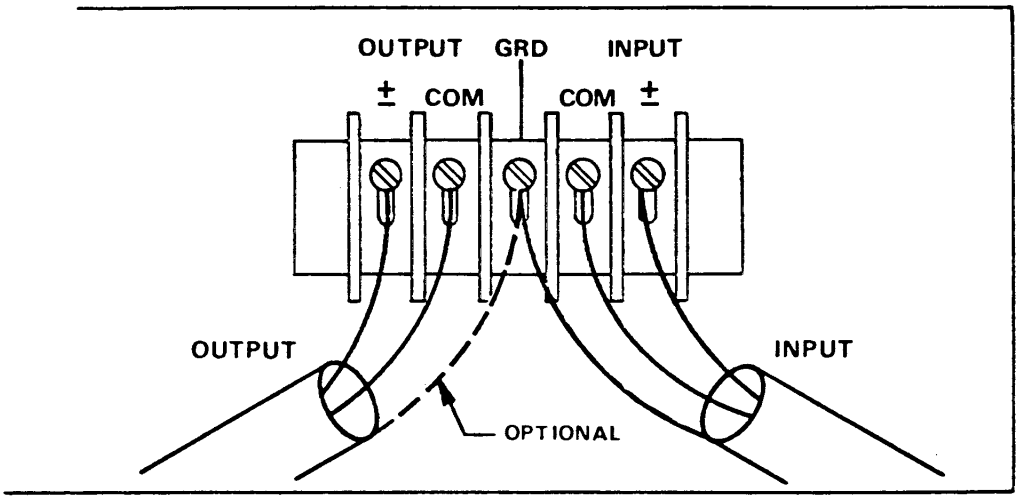


FIGURE 2. CONNECTING THE MODEL 539 WITH BALANCED INPUT AND BALANCED OUTPUT CIRCUITS.*

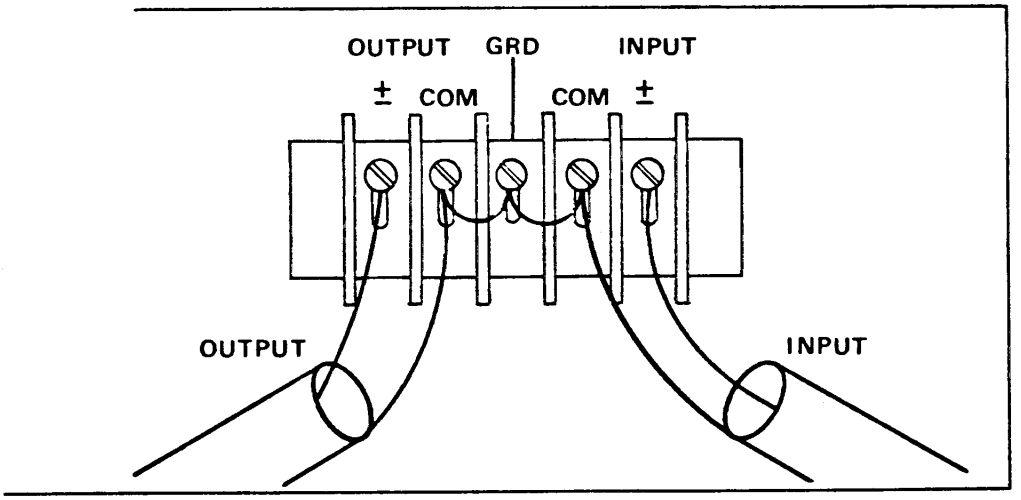


FIGURE 3. CONNECTING THE MODEL 539 WITH UNBALANCED INPUT AND UNBALANCED OUTPUT CIRCUITS.*

*With a balanced input and unbalanced output, or vice-versa, use the appropriate connections suggested by each of the above diagrams. No special switching or transformers are needed.

2.6 IMPEDANCE AND TERMINATION

Audio engineering had its roots in the telephone industry, and "600 ohm circuits" (together with their predecessors, "500 ohm circuits") are carry-overs from telephone transmission practices. Long audio transmission lines, like their video counterparts, must be properly sourced from and terminated in equipment which matches their characteristic impedance, if optimum frequency response and noise rejection are to be achieved.

However, transmission line theory and techniques are not only unnecessary but impractical within modern recording studios, broadcast studios and other local audio systems where transmission circuits are seldom more than several hundred feet in length. The advent of negative feedback circuitry and solid-state electronics has spawned modern audio amplifiers and other signal processing devices having source impedances of only a few ohms. They are essentially indifferent to load impedances and by varying their output current inversely to changes in load impedance, maintain the same output voltage into any load impedance above a rated minimum, with no change in frequency response.

Modern audio systems, therefore, utilize amplifiers and other active devices which have very low output impedances and high (10K to 50K) input impedances. These products may thus be cascaded (operated in tandem), or many inputs may be connected to a single output of a preceeding device, without regard to impedance "matching". Switching, patching, etc. is simplified because "double loads" and "unterminated" bugaboos are essentially eliminated. "Floating" (ungrounded) transformer outputs minimize ground loop problems, and differential transformerless input circuitry (or input transformers) minimize common mode noise or interference which may be induced into the interconnecting wires or cables.

Where audio must be transmitted through cables or wire pairs of more than several hundred feet in length, however, transmission line termination practices should still be observed.

The Model 539 has an input impedances of 40 kohms (40,000 ohms) when used in a balanced, differential input configuration, and 20 kohms (20,000 ohms) when used unbalanced (one side grounded). This makes the equalizer suitable for use with any normal source impedance, low or high. Only when it is used from a source which requires a low impedance termination (such as a 600-ohm transmission line or older vacuum-tube equipment) is a source termination resistor required at the 539 input.

2.7 SIGNAL LEVEL AND OVERLOAD DETECTOR

The Model 539's differential input amplifiers are capable of being driven by signals up to a level of +20 dBm, above which clipping occurs. The overload LED flashes when signal peaks approach the clipping level, and it will remain on long enough to be seen even if the excess signal is only a brief transient. When the LED indicator flashes more than occasionally, either lower the output level of the source feeding the equalizer, or use an external attenuation pad to avoid audible distortion.

The signal level is also monitored at the output stage, since it is possible to overload the output amplifier with the gain control of the equalizer. The Model 539 is capable of delivering +24 dBm into a 600 ohm load (12.3 volts) or +26 dBm (7.75 volts) into a 150 ohm load.

2.8 ACCESSORIES

Security Cover and Knobs for 1/3-Octave Filter Controls.

When the Security Cover is installed over the 539 front panel, all controls are protected from unwanted misadjustment. Only the power switch remains accessible. The smoke gray plexiglas cover is transparent enough to view the control settings.

A set of 27 knobs is simply pushed onto the protruding 1/3-octave controls. The knobs are helpful when frequent adjustments are necessary.

SECTION III

OPERATING INSTRUCTIONS

3.1 GENERAL

The main reason for frequency response tailoring of audio systems is to compensate for response anomalies occurring in the system and its environment, and to adjust the system response curve to some desired shape. In some systems this means adjusting for best overall flatness of response through the entire audio range, and in other instances some different response shape is desirable.

Three important characteristics of audio systems may be improved by judicious application of corrective equalization techniques. They are:

(1) DISTORTION OF FREQUENCY RESPONSE BALANCE.
Sources of sound which may be amplified through a sound system start out with some specific frequency bands. If, in being processed through an audio system this balance is disturbed by variation in frequency response, then truly the sound has been distorted. For example, a clarinet has a specific characteristic with regard to the levels of the various harmonics compared to the fundamental tone. If these signals are processed through an audio system with non-linear frequency response, then the resultant sound is simply not the distinctive sound which that clarinet originally produced.

(2) SUSCEPTIBILITY TO FEEDBACK.
In public address and sound reinforcement systems, the maximum acoustic gain that may be obtained for a microphone in the vicinity of a loudspeaker which is part of that system, will be determined by the positive feedback loop created when sound from the loudspeaker enters the microphone, reinforcing the signal level until the system goes into oscillation. This positive feedback problem is aggravated if some frequencies in the audio range are reproduced at a higher level than the rest of the frequency band. If the level of these frequencies which are being reproduced at an exaggerated level can be reduced, then the sound system gain may be increased to some degree without feedback.

(3) INTELLIGIBILITY.
For an audience in an auditorium to understand a lecturer, or for a nightclub audience to hear the words which a vocalist is singing, there are two important requirements:

(a) The sound level of the source must be sufficiently loud as to be heard clearly and not masked by other sounds which may be present in the listening environment.

(b) The sound which the listener hears must be intelligible to him. It should not be distorted or garbled. There are a number of causes for poor intelligibility in a sound system. Among them are: amplifier or speaker distortion, frequency band masking, improper balance of direct and reverberant fields, and inadequate projection of the higher frequencies which are necessary for the recognition of words. The frequency band from approximately 1 kHz to 5 kHz is very important to the recognition of sibilant and consonant sounds, and if the sound system has inadequate output in this frequency band, or if other bands have considerably greater output which "cover up" the sounds in the intelligibility band, the words may simply not be understood. Equalization is very helpful to correct some of these problems.

The remainder of this section is concerned with a general description of the equalization process and some suggestions for successful application of the Model 539 are given. Techniques are continuously being improved upon, therefore this discussion should be considered only as a starting point for those who are new to the field, and as a general review for those who are already proficient in the methods used.

Those interested in more complete information on the general subject of sound system design and corrective equalization are encouraged to study specialized literature* and/or participate in seminars dedicated to audio acoustics, etc.

An excellent series of continuing seminars are conducted in various cities by Don and Carolyn Davis. For further information, and a schedule of their regular seminars, contact:

"Synergetic Audio Concepts"
P.O. Box 1115
San Juan Capistrano, CA 92693

* Sound System Engineering, by Don and Carolyn Davis, Published by Howard W. Sams, Inc., Indianapolis, Indiana 46268, Copyright 1975.

3.2 BEFORE EQUALIZATION

Corrective equalization is only one of the solutions to the problems faced by designers or users of audio systems. Applied correctly, it is a powerful tool; but if it is assumed to be a cure-all without careful consideration of other possible alternatives, results may be disappointing. If the sound systems is not thoroughly checked out before equalization procedures are attempted, much time may be wasted. Therefore we feel that it is important to mention a few of the tests which should be made prior to the start of corrective room equalization. The list is not intended to be exhaustive, rather to point out that unless you know what the sound system IS doing, you may find it difficult (if not impossible) to make it do what it SHOULD do.

A PARTIAL CHECK-LIST OF PROCEDURES BEFORE EQUALIZATION:

(1) At normal operating levels, check the frequency response and the signal-to-noise and distortion characteristics of the individual components of the system and the system as a whole.

(2) Check phasing of signal lines from all inputs through to the amplifier outputs.

(3) Check loudspeakers to see that all units function, that there are no rattles due to loose screws or units poorly attached to walls. Check phasing of all loudspeakers, even of the several drivers within one cabinet. Check loudspeaker aiming.

(4) Check phasing of all microphones.

(5) Check that all electronic components of the system are connected correctly, that correct signal levels are observed, that loads are where they should be and not where they should not be. Check the system for oscillations, R.F. interference, and hum.

(6) Make sure you have a good system ground, and that shielding and grounding are done in accordance with good practices.

(7) Make sure that the AC electrical power to the system is of good quality, adequately protected, and that the wire size is sufficiently large to avoid excessive voltage drop when large amounts of power are drawn.

3.3 MEASUREMENT TECHNIQUES

Several different methods are in use to measure the frequency response characteristic of a sound system in its acoustic environment:

(1) Pink noise, measured in 1/3-octave bands and displayed on a real time spectrum analyzer or suitable LED-display.

(2) Swept sine waves, measured on an audio voltmeter or plotted on a graphic recorder.

(3) Swept sine waves, frequency modulated with a constant percentage bandwidth (Warble Tone) generated and plotted with the UREI 200/2000 Recorder system.

(4) Pulsed signals, generated and measured with the UREI SONIPULSE™ system.

(5) Other methods, as for example "Time Delay Spectrometry," are in the development stage and may become important alternate solutions in the future.

Basically, all of the measurement methods are similar in technique -- differing only in hardware. They all involve generating a known quantity of audio signal, transmitting it through the sound system, and reading the results through a calibrated microphone and readout device. The results will closely resemble each other if comparative measurements are made, presuming correct application of the various methods.

The microphone is located in the listening area, and its position is changed to see if there are response variations in different locations. The response variations are then averaged together to make what is called the RAW HOUSE CURVE (Figure 4). Corrective equalization procedures are based on this curve. Many problems associated with level balance between multiple speakers in large areas, acoustic deficiencies, and speaker aiming and locating faults will show up on the curves taken in various locations in the listening area. For good results, these faults should be corrected by re-balancing of levels and re-aiming or relocating speakers -- not by equalization. In systems which use electronic crossovers or multi-amplifier configurations, the balance should be checked and adjusted between low and high frequencies and between speakers covering different parts of the listening area.

3.4 ADJUSTMENT OF EQUALIZERS

Room equalization is performed as a series of approximations of control settings. Looking at the sample RAW HOUSE CURVE in Figure 4, we can infer that if an inverse electrical response curve were placed in the audio chain that the result would be a flat frequency response.

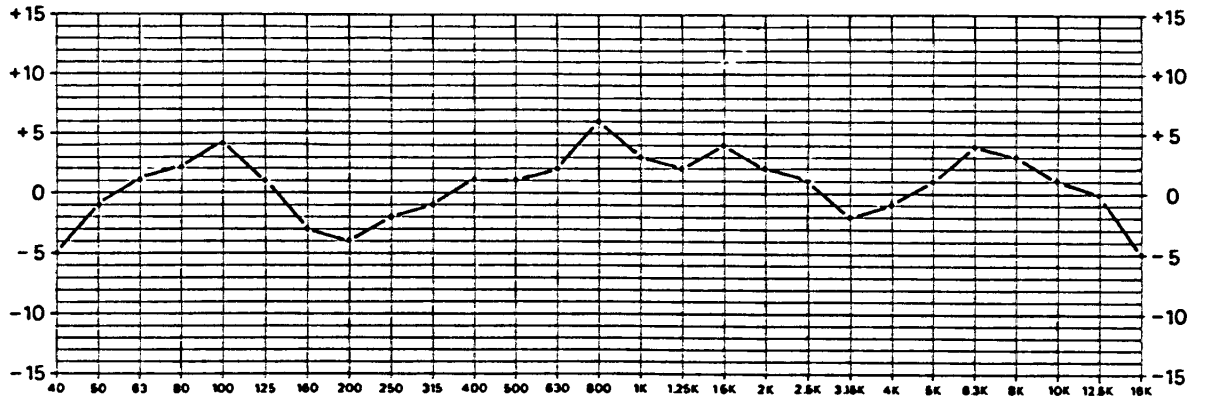


FIGURE 4.
TYPICAL RAW HOUSE CURVE OBTAINED FROM SONIPULSE™ MEASUREMENTS.

OCTAVE OR 1/3-OCTAVE EQUALIZERS?

The octave graphic or 1/3-octave graphic equalizers are tools with which this inverse curve is approximated. Because there are combining effects between adjacent filters, it is necessary to make settings on the equalizer and then to re-check the room response to see if the adjusments were correct. Additional adjustments and measurements may be made until the desired results are obtained.

It is important to understand the difference between these equalization filters. If the device contains filters which are one octave wide (such as the single channel UREI Model 533 or the dual channel Model 535), the user is able to adjust for broad spectrum anomalies, which in some applications is absolutely sufficient. However, the 1/3-octave equalizer, with its 27 controls plus end cut filters, enables a much more precise adjustment to correct the frequency response in the system.

3.5 SOME PROBLEMS WITH CORRECTIVE ROOM EQ

As stated earlier, the process of corrective equalization of sound systems is not a cure-all. There are some rooms which, because of very long reverberation times and poor acoustic configuration, cannot be significantly improved. There are a few others

in which the acoustics and the sound system are already so well balanced that there is little need for correction. It is for the majority of situations which lie between unsolvable and relatively perfect that corrective equalization is intended.

Many of the problems that people seem to have when performing corrective equalization stem from a tendency to "overkill." It has been found in practice that it is not desirable to attempt to equalize to the "last dB" all minor anomalies in the response of an acoustical system, as this often results in an artificial or processed sound. Also, it sometimes requires extreme filter settings with introduction of unwanted phase shift, which may cause more problems than the EQ solves. In general, if the final results are within a 3 dB envelope of the desired theoretical values, the equalization should be considered successful.

Attention should also be given to the fact that different frequencies are attenuated differently when traveling through air. As the distance between the sound source and the listening position (or position of the measuring microphone) increases, it is natural for high frequencies to be attenuated more. Therefore, if equalization is adjusted to create a perfectly "flat" response, particularly throughout a large room, the resulting sound will be excessively bright. A house curve which produces a natural response in sound systems is subjective and a matter of personal preference, as well as a function of the primary use of the location. However, a flat response up to about 3 kHz and then an attenuation of 3 dB per octave above 3 kHz is frequently used in sound reinforcement. In recording studios and monitoring rooms, the response is usually flat to higher frequencies.

Widely disparate settings of adjacent controls should be avoided if at all possible. A control panel in which adjacent adjustment knobs are 8 to 10 dB apart may look interesting, but the resultant sound will not be natural. It is good to remember that the trained human ear is still the ultimate judge of any equalization.

3.6 FEEDBACK SUPPRESSION

An improvement of a system's tendency to feedback should be attempted after the general equalization of the frequency response is performed. SLOWLY advance the gain until the feedback frequency becomes detectable and stabilize the feedback to a constant, comfortable level. (Caution: feedback is not only annoying to the ear, but it is also dangerous to unprotected amplifiers and loudspeakers!). The control which reduces the feedback with a minimum of additional attenuation is closest to the actual feedback frequency. Experimentation by trial and error, and the resulting experience, is the best method.

Advancing the gain further will cause the next feedback frequency to occur. This procedure may be repeated as often as it seems practical. Again, extreme filter settings should be avoided.

The result will be a higher amplifier gain setting than was possible before feedback suppression. Remember: an improvement of 3 dB is equal to twice the previously available power. To prevent ringing, it is best to adjust the gain at least 3 dB below the threshold of feedback.

NOTE: Where the budget allows the expense, we suggest to add a dedicated instrument, the UREI Model 560 Feedback Suppressor to the system. It is specifically designed to "tune-out" a very narrow band of frequencies with continuously variable filters without noticeably altering the program material.

3.7 LOW CUT AND HIGH CUT FILTERS AFTER CORRECTIVE EQ

Examination of the filter's frequency response characteristic after equalization adjustments have been made may show that the band ends (low and high frequency extremes) could overdrive the amplifier or speakers if the program material contains energy at these frequencies, i.e. microphone pops, etc. Adjust the tunable low cut and high cut filters until the resulting system response curve looses its "bathtub" shape and the house curve rolls off smoothly at each end.

3.8 HIGH CUT FILTER CHARCTERISTIC, 12 dB or 6 dB/OCTAVE

This switch-selectable feature was added to change the house curve quickly without readjusting the individual 1/3-octave controls. As may be seen in Section VI, Figure 6, the 12 dB/octave setting provides a rather sharp cutoff point, while the initial attenuation of the 6 dB/octave filter is more gradual. This is very useful in situations where frequent changes of high frequency response are required, as in control and monitor rooms, to adjust to different program material or producers' taste. The filter skirts intersect at the continuously variable -3 dB point.

3.9 GAIN STRUCTURE AND SIGNAL-TO-NOISE

Only the correct gain structure throughout the entire audio system will enable the user to take advantage of the optimum signal-to-noise ratio built into the individual components. In this discussion, the matching between the equalizer and a following power amplifier is considered.

The Model 539 was designed for an average signal level at its input of approximately 0 dBm. This guarantees 20 dB of headroom; that is, peaks may be 20 dB above the average level before any clipping could occur. Residual output noise from the Model 539 is 90 dB below the average signal level, or 110 dB below maximum output level, and therefore inaudible.

The specification of the power amplifier may state an input sensitivity of 0.775 volts (0 dBm) for maximum output power. This means that any signal level which is greater than 0 dBm causes overload of the amplifier. As stated before, the maximum output level from the equalizer may have peak values of approximately +20 dBm. Obviously, the equipment is not properly matched!

Two solutions shall be discussed:

(1) We reduce the input level to the equalizer to -20 dBm. Since it is a unity gain device, its output is also -20 dBm average signal level. This value is safe to provide us with 20 dB of headroom in the power amplifier. However, we reduce at the same time our signal-to-noise ratio. As was mentioned before, the residual noise from the equalizer is 90 dB below a 0 dBm reference level. If our average signal level is -20 dBm, only 70 dB of signal-to-noise ratio remains, which may be adequate, but is a limitation.

(2) A better solution would be to leave the average signal level through the equalizer at the optimum level of 0 dBm, but add a 20 dB attenuator between its output and the power amplifier's input. This reduces the average signal level and the residual noise from the equalizer (and other possible sources). The original 90 dB below average signals or 110 dB below peak signals is maintained. In many cases the gain control of the power amplifier may be used as the suggested attenuator (so long as an input stage in the power amplifier will not be overdriven).

3.10 DOCUMENTATION

The very nature of a room equalizer permits an almost infinite number of control settings. For later duplication of a certain sound or a corrective response curve it is necessary to document the position of the controls (Frequency and end cut) This is made convenient by the graphic layout of the Model 539's front panel and its calibrated markings.

In addition, a frequency curve may be drawn with a suitable sweep generator and X-Y Recorder system, such as the UREI Model 200/2000.

SECTION IV

THEORY OF OPERATION

4.1 INPUT AMPLIFIER

The signal is applied to a differential input amplifier (IC-1, sections A and B). The input accepts either balanced or unbalanced sources (see also Installation 2.5 and 2.6). Common mode rejection is factory adjusted with R-2 and is typically better than 40 dB.

The factory set offset adjustment of R-3 assures that no DC voltage is at the output of the following amplifier stage, thus preventing audible clicks when operating the EQ IN-OUT switch. The gain of the input amplifier is -6 dB.

4.2 BANDPASS AMPLIFIER

Through an isolation amplifier (IC-1-C) with a gain of 1.7 dB, the signal is coupled into the bandpass amplifier. This circuit is a voltage controlled voltage source (VCVS) combining the frequency determining elements for Low Cut and High Cut controls. The filter has Butterworth response, and one pole-section of the High Cut filter is switch-selectable, changing the slope from 12 dB/octave to a more gradual 6 dB/octave rolloff. The slope of the Low Cut filter rolloff is always 12 dB/octave. The -3 dB points of both filter sections are independently variable from 20 Hz to 250 Hz and from 3.5 kHz to 20 kHz respectively.

The resistors R-13 and R-14 in the feedback loop of IC-1-D provide a gain of 4.3 dB which restores unity gain with respect to the input signal level.

4.3 ONE-THIRD OCTAVE FILTERS

There are 27 individual L-C networks in the equalizer. They are divided into four groups. Two groups each are designed to be the feedback/feedforward circuit around amplifiers IC-2, sections C and D. Figure 5 (next page) shows a simplified schematic of the circuit.

Since resistors Rd and Re are of equal value, the op amp works as a unity gain inverting amplifier. Resistor Ra and potentiometer Rb are also of equal value. The junction "X" is fed by two signals which are the same in amplitude but 180° out of phase. Therefore the voltage at this point is zero. The wiper of the potentiometer Rb is connected to a tuned circuit consisting of Rc, C and L. If the wiper of Rb is moved to point "X", no signal can flow through the series circuit (0 dB position of the 1/3-octave control on the front panel).

As the wiper is moved through the resistance of Rb, increasing negative feedback is applied to the op amp for those frequencies which are passing through the tuned circuit and reducing their gain in the amplifier. The result is the desired attenuation in the equalizer's frequency response. If adjacent filter sections are adjusted, their effects combine smoothly without unwanted characteristics (ripple, phase shift, etc.) Also, see graphs in Section VI. Resistors Ra and Rb are fed through isolating buffer amplifiers (IC-3 and IC-4). In addition, phase correcting networks (R-42,43, C-25, etc.) ensure loop stability and good transient response.

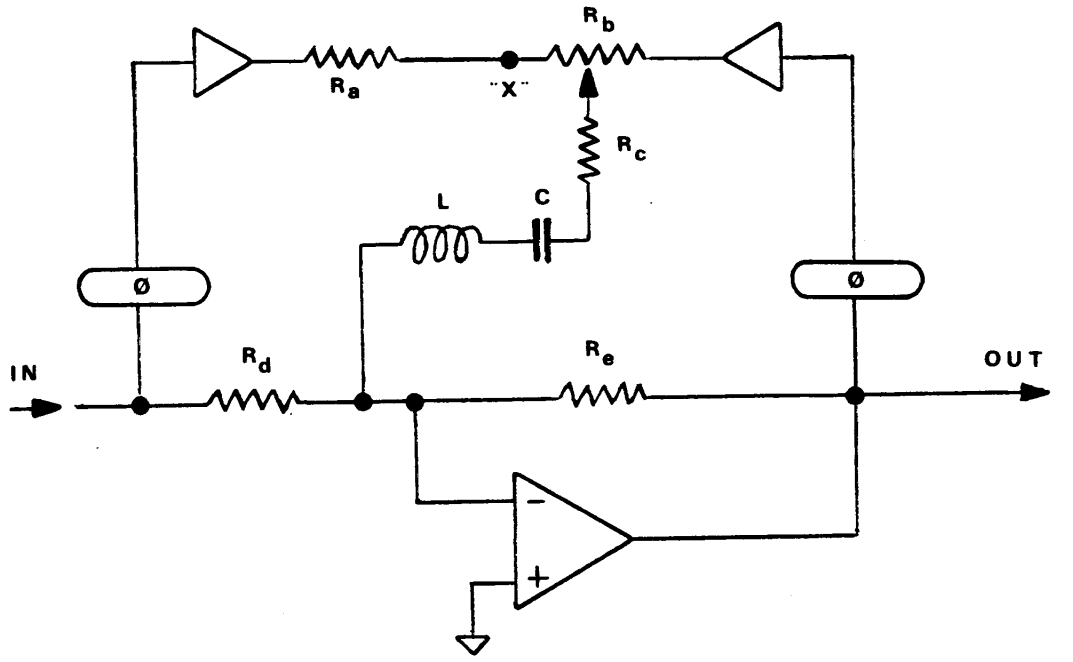


FIGURE 5. SIMPLIFIED 1/3-OCTAVE FILTER SECTION.

4.4 EQ IN-OUT SWITCH

A loss pad of 4.3 dB at the output of the filter section matches the signal level to the output of the isolation amplifier (IC-1-C). The result is that no level change occurs when switching the equalizer section IN or OUT if none of the frequency controls are adjusted for attenuation. In the EQ IN position, the signal is coupled through C-14 and R-24 into the output amplifier. In the EQ OUT position, the output of the isolation amplifier (IC-1-C) is also connected to the output amplifier. However, since the output impedance of IC-1-C is very low, the signal from the filter section is effectively short circuited.

4.5 OUTPUT AMPLIFIER

The output stage is a high performance op amp (IC-5) which drives a complementary pair of output transistors. In the IN position of the EQ switch, the gain is adjustable between +1 dB and +21 dB, depending on the ratio of R-26, 27 & 28. In the OUT position, the variable gain control (R-28) is defeated. The output transformer has a gain of 3 dB when terminated with a 600 ohm load, thus restoring unity gain through the entire Model 539 (EQ OUT).

4.6 OVERLOAD DETECTOR

Under normal signal level conditions, the output of IC-2-B is positive due to the negative bias at its inverting input. The LED is turned OFF. If the signal levels from the input amplifier through diode CR-10 and/or from the output amplifier through CR-11 and R-36 exceed the threshold adjusted by the ratio of R-35 and R-37, the overload detector amplifier changes its output state. Now the LED conducts and indicates an overload condition.

A pulse-stretching network is included in the positive feedback loop of the amplifier to ensure that the LED is ON long enough to be observed, even though the overload may have been caused by a very short duration signal peak.

4.7 POWER SUPPLY

The power supply is bipolar, employing two integrated circuit voltage regulators VR1 and VR2 to provide low-ripple, ±18 volt DC. Additional filter capacitors assure power supply stability and low noise.

The pilot LED is connected to the positive side of the power supply to indicate power ON condition.

SECTION V

MAINTENANCE

5.1 GENERAL

The Model 539 is an all solid-state unit, ruggedly constructed with only the highest quality components. As such, it should provide years of trouble free use with normal care. All parts used are conservatively rated for their application, and workmanship meets the rigid standards you have learned to expect in UREI products.

NO SPECIAL PREVENTIVE MAINTENANCE IS REQUIRED.

REPAIRS AND WARRANTY

This product is factory warranted to the original purchaser against defects in material and workmanship for one year after initial purchase. This limited warranty must be activated at the time of purchase by returning the registry portion of the Warranty Card to the factory. Should a malfunction ever occur, the dealer from whom the unit was purchased will be glad to handle return for factory repair. Please call or write to the factory for a Return Authorization Number which must accompany all repairs. For prompt service ship the unit prepaid directly to the factory with the RA Number visible on the shipping label. Be sure it is well packed in a sturdy carton, with shock-absorbing material such as foam rubber, styrofoam pellets or "bubble-pack" completely filling the remaining space. Particular attention should be paid to protecting the controls, switches, etc. Tape a note to top of the unit describing the malfunction, and instructions for return. We will pay one-way return shipping costs on any in-warranty repair.

Because of specially selected components in this product, field repairs are not authorized during the warranty period, and attempts to perform repairs may invalidate the warranty.

5.3.0 SERVICE ADJUSTMENTS

These controls have been carefully set at the factory and should not require adjustments except after service work.

5.3.1 COMMON MODE BALANCE

The internal trimpot R-2 affects the COMMON MODE BALANCE. If a check or an adjustment is necessary the following procedure should be followed:

Connect the ± and COM input terminals together and apply an input signal between this connection and the GND terminal (100 Hz, 3 V rms).

Switch the EQ OUT and measure the signal with an AC VTVM or DVM across the output terminals of the Model 539. Adjust the trimpot R-2 for a minimum reading, switching the voltmeter gradually to more sensitive ranges.

5.3.2 OFFSET ADJUSTMENT

The internal trimpot R-3 affects this adjustment. It should only be necessary to change the factory setting if IC-1 and/or IC-5 are replaced. The adjustment is correct when the DC output of IC-1-C is 0 VDC. Since there is no offset voltage at the input of IC-5, no "click" will be generated when the EQ switch is operated.

NOTE: If the offset control is severely misadjusted, large voltage pulses are generated in the equalizer when the EQ switch is operated. This could overload or damage unprotected equipment which may be connected to the output of the Model 539. UREI cannot be responsible for consequential damages due to misadjustment of this control.

PREFERRED METHOD

Adjust R-3 for 0 VDC at the output of IC-1-C (yellow wire at the EQ switch).

ALTERNATE METHOD

Connect the output terminals of the Model 539 to a high gain amplifier and loudspeaker. With no input signal applied switch the EQ IN and OUT.

Listen to the loudspeakers and adjust R-3 for minimum audible "click" while operating the EQ switch.

5.4 ON OP AMPS

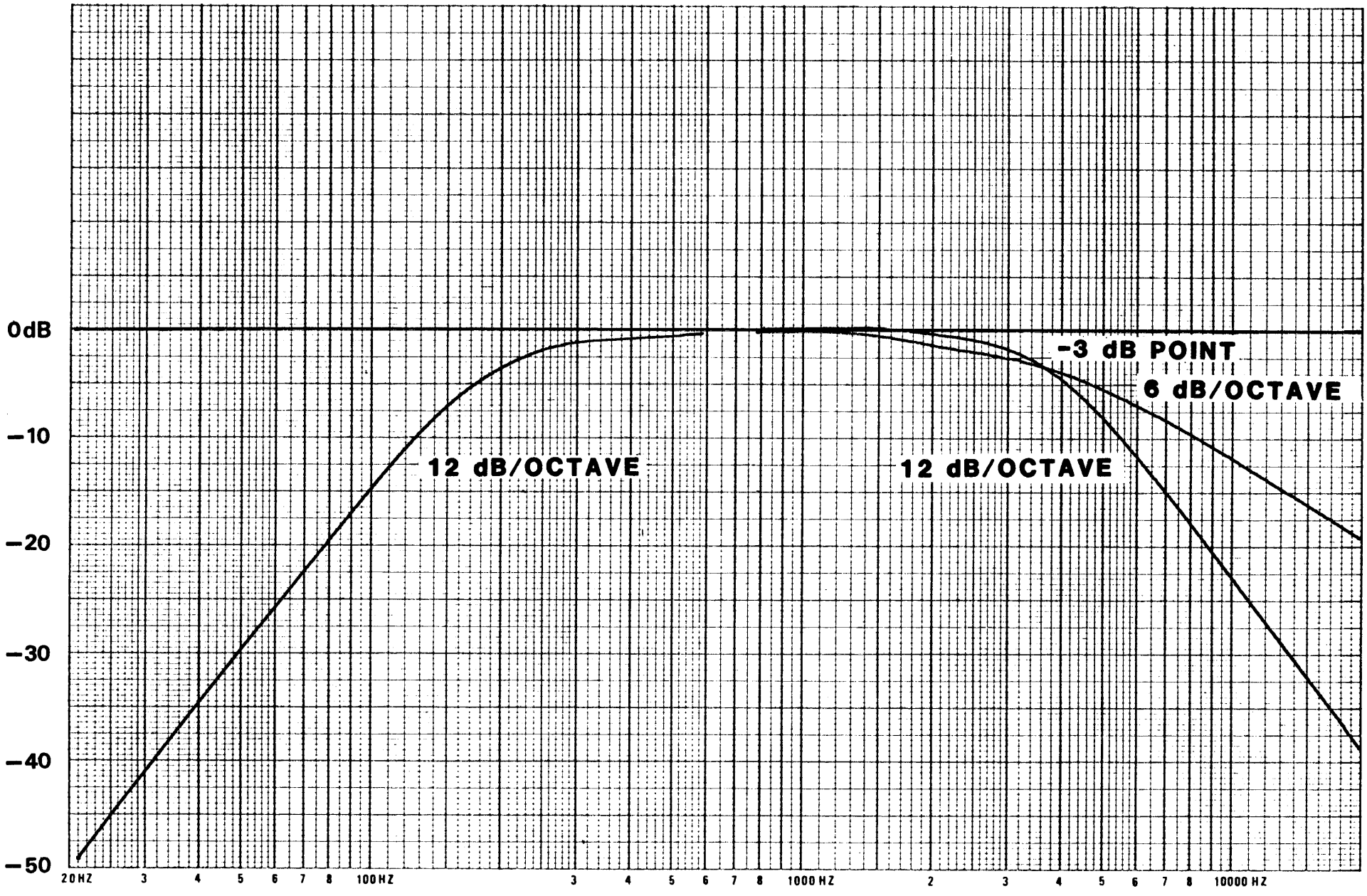
The Model 539 Room Equalizer has been designed making extensive use of integrated circuit operational amplifiers (IC op amps). During the last several years, much research and development work has been done by the semi-conductor manufacturers to improve their products, and more is anticipated. We expect that better op amps at lower cost will be available as this development work continues. At the time of the design of the Model 539, we anticipated this and have made every effort to design the circuit so that as improved parts become available they may be incorporated into the Model 539 with little, if any, modification. We also realize that occasionally an IC will fail. For this reason, the table below lists a number of different operational amplifiers which will function as direct, pin-for-pin replacements for the op amps in the 539. For one reason or another, they may not function as well as

the op amps originally supplied with this unit, but for emergency repairs, if the original types are not available, these will get the instrument back into service.

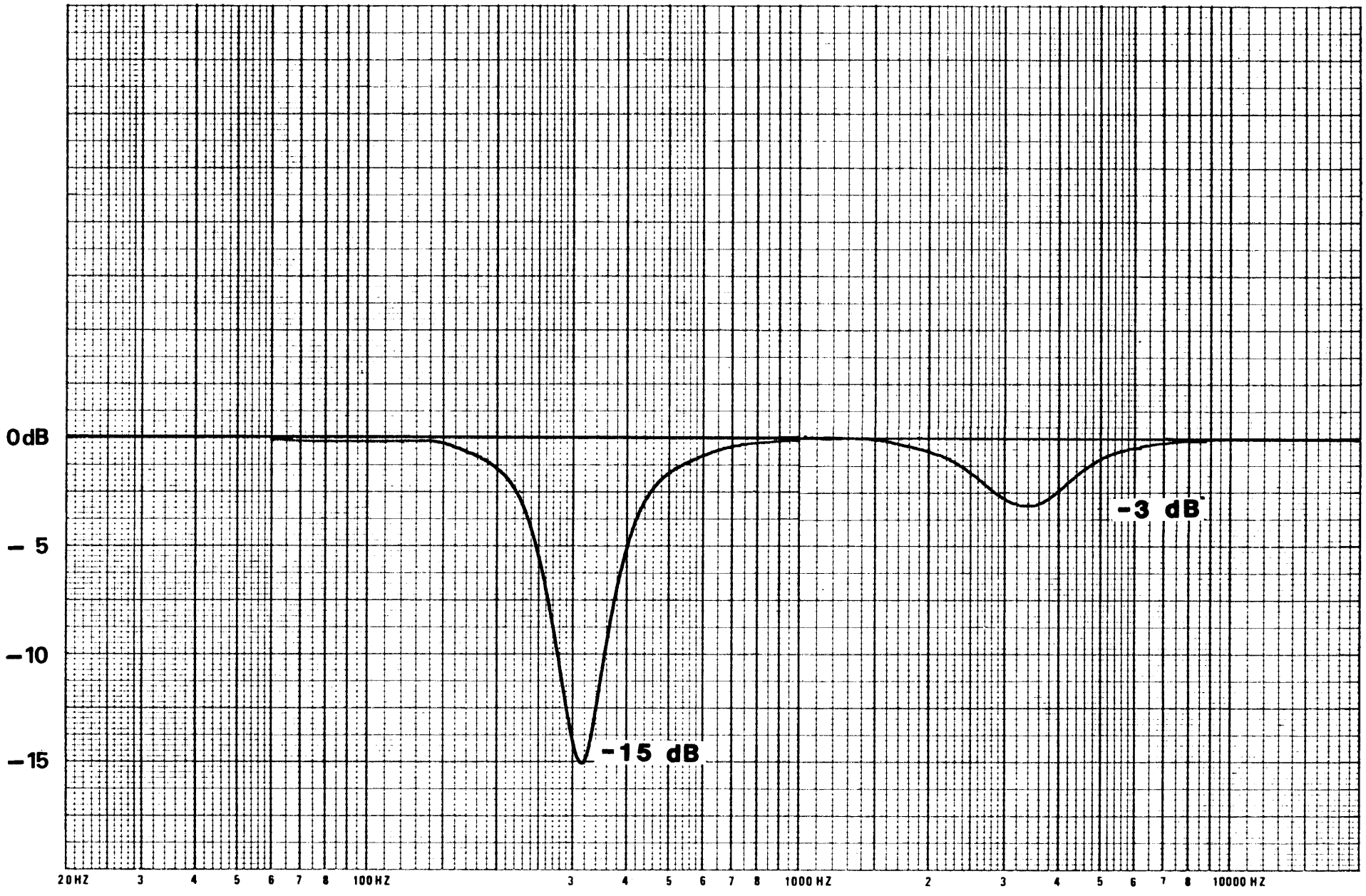
	MODEL or TYPE	MANUFACTURER
IC-1 THROUGH 4		
ORIGINAL	HA 4741-5	HARRIS
REPLACEMENTS	HA 4741-5	RAYTHEON
	TL 074	TEXAS INSTRUMENTS
	TL 084	TEXAS INSTRUMENTS
	LM 347	NATIONAL SEMICONDUCTOR
IC-5		
ORIGINAL	TL 071 CP	NATIONAL SEMICONDUCTOR
REPLACEMENTS	LM 301 J*	NATIONAL SEMICONDUCTOR
	LF 351 N	NATIONAL SEMICONDUCTOR
	TL 080 CL*	TEXAS INSTRUMENTS
	TL 081 CL	TEXAS INSTRUMENTS
	TL 070 CL*	TEXAS INSTRUMENTS

All of the above "replacement" op amps should be considered interim replacements until the correct "original" device can be obtained and substituted. IC 3 and 4 must be of the same type.

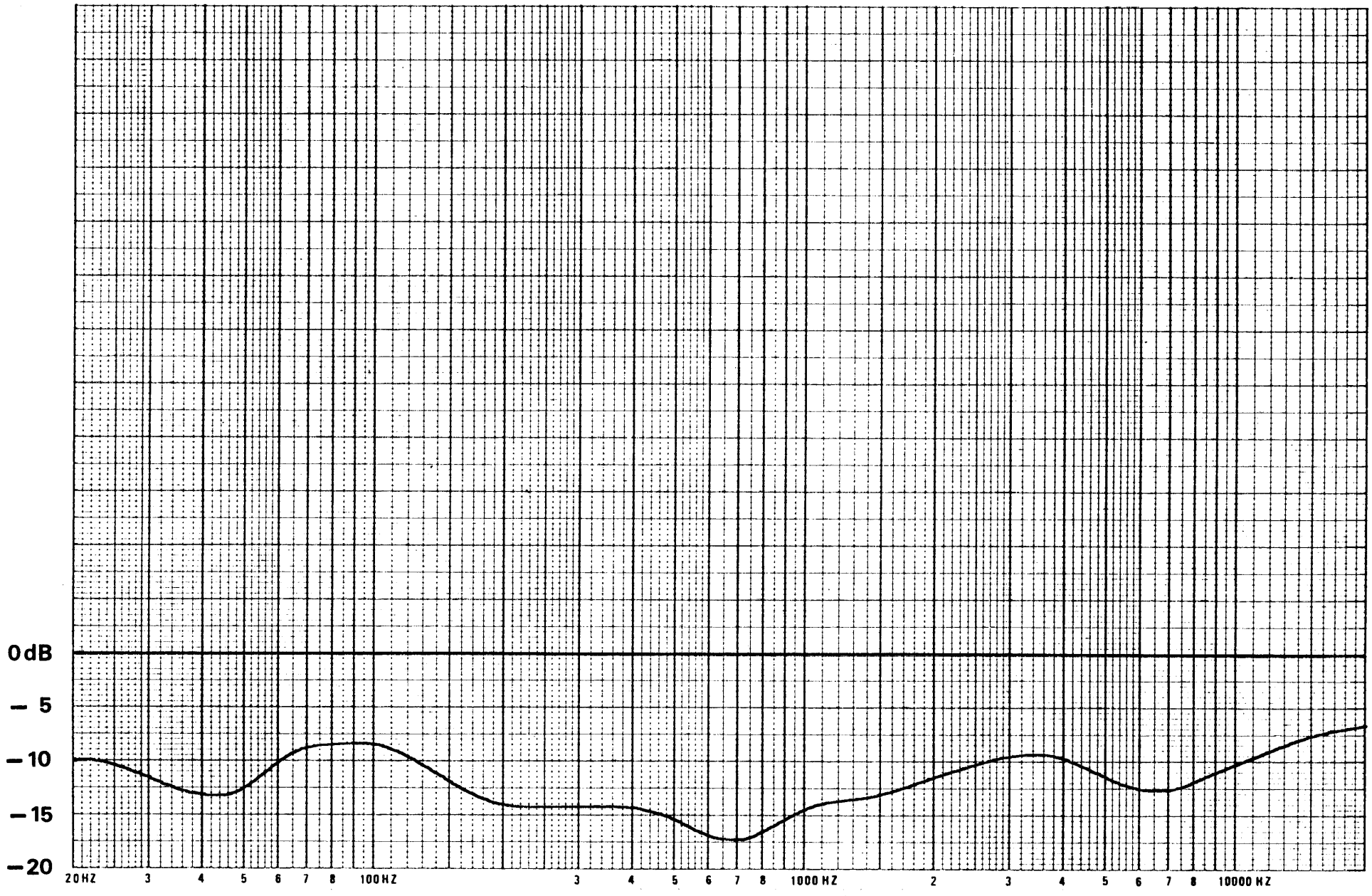
*Requires addition of a 30 pf compensation capacitor between pins 1 & 8. Space is available on the PC board.



TYPICAL L.F. CUT, H.F. CUT RESPONSE



INDIVIDUAL FILTERS, ATTENUATED 15 dB AND 3 dB



COMBINING ACTION OF FILTERS AT TYPICAL E.Q. SETTING

INPUT AMPLIFIER

BANDPASS AMPLIFIER

OVERLOAD DETECTOR

OUTPUT AMPLIFIER

GROUND FOLLOWER

ONE-THIRD OCTAVE FILTERS

POWER SUPPLY

GROUP 1

F	L	COLOR	C#	C	* Rc	P#
40Hz	63H	BRN	31	0.25	100	P2-1
100	25	GRN	35	0.1	750	P2-6
250	10	ORG	39	0.04	1.3K	P2-10
630	4	VIO	43	0.016	1.2K	P2-15
1.6K	1.6	BRN	47	0.0063	1.5K	P3-4
4K	0.63	GRN	51	0.0025	1.8K	P3-8
10K	0.25	WHT	55	0.001	2K	P3-13

GROUP 2

F	L	COLOR	C#	C	* Rc	P#
50Hz	50H	RED	32	0.2	240	P2-2
125	20	BLU	36	0.08	1K	P2-7
315	8	YEL	40	0.0315	1.3K	P2-11
800	3.15	GRY	44	0.0125	1.2K	P3-1
2K	1.25	RED	48	0.005	1.8K	P3-5
5K	0.5	BLU	52	0.002	1.8K	P3-10
12.5K	0.2	B/W	56	0.0008	2.4K	P3-14

GROUP 3

F	L	COLOR	C#	C	* Rc	P#
63Hz	40H	ORG	33	0.16	470	P2-3
160	16	BRN	37	0.063	1K	P2-8
400	63	GRN	41	0.025	1.5K	P2-12
1K	2.5	WHT	45	0.01	910	P3-2
2.5K	1	ORG	49	0.004	1.8K	P3-6
6.3K	0.4	VIO	53	0.0016	2K	P3-11
16K	0.16	R/W	57	0.00063	2.4K	P3-15

GROUP 4

F	L	COLOR	C#	C	* Rc	P#
80Hz	31.5H	YEL	34	0.125	620	P2-5
200	12.5	RED	38	0.05	1.3K	P2-9
500	5	BLU	42	0.02	1.3K	P2-14
1.25K	2	B/W	46	0.008	910	P3-3
3.15K	0.8	YEL	50	0.0315	1.8K	P3-7
8K	0.315	GRY	54	0.00125	2K	P3-12

9. * INDICATES NOMINAL VALUES. MAY VARY IN PRODUCTION.
8. EQUIVALENT SEMICONDUCTOR DEVICES MAY BE SUBSTITUTED IN PRODUCTION.
7. ⟶ INDICATES CLOCKWISE ROTATION.
6. □ INDICATES P.C. CONNECTOR TERMINATION.
5. ○ INDICATES WIRE TERMINATION ON P.C. BOARD.
4. (INT.) INDICATES INTERNAL SERVICE ADJUSTMENT.
3. (F.P.) INDICATES FRONT PANEL CONTROL.
2. CAPACITOR VALUES ARE IN MICROFARADS.
1. RESISTOR VALUES ARE IN OHMS ± 5%, 1/2W.

NOTES: (UNLESS OTHERWISE SPECIFIED).

THIS SCHEMATIC APPLIES TO UNITS WITH SERIAL NUMBER SUFFIX 'B'

REV L: TL084 ICs WERE A1471. DCN 08-07-02-IY, 2-25-87
REV K CHG SLIDE POTS & MOVED Rc RESISTORS TO MATHEY PCB 12-19-85
REV J PER ECO-022 6-3-85 MBM
REV H PER ECO-021 1-10-83 R.P.M.
REV G PER ECO-020 11-17-82 R.P.M.
REV F PER ECO-018 2-15-82 R.P.M.
REV E ECO-0539-017 8-27-81 PG
REV D REVISE CIRCUIT. 539 BECOMES 539 SUFFIX(A) 3-22-79 R.P.M.
REV C PER ECO-0539-004 5-10-78 BDM
REV B. PER ED 0201 3-14-78 R.P.M.
REV A CHANGE TRANS. FORMER T1 2-8-78 R.P.M.

SCHEMATIC
ROOM EQUALIZER

SIZE	MODEL NO.	DRAWING NO.
R	539	12916 L

DATE 1-24-78 SHEET 1 OF 1