Electro-Voice®
a MARK IV company

Model XEQ-3 Electronic Crossover

SPECIFICATIONS

Channel Configuration:
Monaural three-way, switchable to monaural two-way

Filter Type:
Fourth-order Linkwitz-Riley (24-dB-per-octave attenuation)

Crossover Frequencies, Switch Selectable (see text for other possible frequencies),
Low-Mid:
80, 125, 160, 250, 500 and 800 Hz
Mid-High:
500, 800, 1,250, 1,600, 5,000 and 8,000 Hz

Output Delays,
Type:
Fourth-order all-pass, continuously variable time constant, linear control scale
Range:
Low: 6 µs ("0") to 6 ms
Mid: 1 µs ("0") to 1 ms
High: 0.3 µs ("0") to 0.3 ms

Infrasonic Speaker Protection,
Filter Type:
Second-order Butterworth (12-dB-per-octave slope)
Corner Frequencies:
16 or 32 Hz, provided by supplied HP16/32 plug-in module (see text for other frequencies)

Equalization for "Step-Down" Operation of TL Bass Speaker Systems,
Filter Type:
Second-order underdamped (12-dB-per-octave rolloff below plus-6-dB peak-boost frequency)
Peak-Boost Frequencies:
29, 35, 45 and 60 Hz provided by optional EB29/35 and EB45/60 plug-in modules (see text for other frequencies)

Equalization of Mid- and High-Frequency Outputs, Provided by Plug-In Module,
Normally Supplied:
EQF module (for flat electrical frequency response)
Optional Modules, for Flat Acoustic Response of Compression Drivers on Constant-Directivity Horns:
EQA, EQB...(see Table 1 for complete list)

Input,
Type:
Active differential
Maximum Level:
+18 dBu
Impedance:
20,000 ohms
Common-Mode Range:
±24 V (net of signal voltage)
Common-Mode Rejection Ratio, Typical:
55 dB
Connector:
Female 3-pin XLR type

Main Outputs,
Type:
Floating differential (TRB-2 set of three isolation transformers available; see text)
Maximum Level:
+18 dBu
Impedance:
100 ohms
Minimum Load Impedance for Full Output Level:
600 ohms
Protection:
Safe for short circuit or 25 volts dc
Connectors:
Male 3-pin XLR type

Low-Mix (common-bass) Output,
Impedance:
1,800 ohms
Connector:
RCA-type phono jack

Gain,
Level Controls at Center Detent:
Unity
Adjustment Range re Unity Gain, Continuously Variable:
±12 dB

Frequency Response, Sum of Outputs, Level Controls at Center Detent, 2,000-Ohm Loads:
20-20,000 Hz 0.5 dB

Total Harmonic Distortion, 20-20,000 Hz,
Typical:
0.02%
Maximum:
0.1%

Noise, Each Output, Controls Flat, 20-20,000-Hz Noise Bandwidth, Typical:
90 dBu

Channel Crosstalk, Typical:
78 dB

Transient Performance:
Not limited by slew rate or power bandwidth under any normal operating condition, 20-20,000 Hz

LED Level Indicators (level-dependent brightness provides enhanced resolution),
Green:
Input level above 20 dBu
Yellow:
Input level above 0 dBu
Red:
Input or any output level above +16 dBu

Front-Panel Controls, Each Output:
Gain, delay, polarity and channel mute

Chassis Construction:
Painted aluminum

Colors:
Black with white graphics

Mounting:
Standard 19-in. rack panel, 1¾ in. high, 7 in. deep behind panel

Supplied Accessories:
HP16/32 plug-in high-pass filter module for 16- or 32-Hz low-frequency protection; BMK blank plug-in module for construction of custom modules; smoked acrylic security cover

Optional Accessories:
EQA, EQB...plug-in equalization modules for flat acoustic response of compression drivers on constant-directivity horns (see Table 1 for complete list); TRB-2 set of three output isolation transformers

Power Requirements:
100-120 V ac, 50-60 Hz, 10 W (also available for 80-110 and 220-240 V ac, 50-60 Hz)

Overall Dimensions (see Figure 1):
44 mm (1.73 in.) high;
483 mm (19.0 in.) wide;
185 mm (7.28 in.) deep

Net Weight
3.1 kg (6.8 lb)

Shipping Weight:
3.8kg (8.4 lb)

DESCRIPTION

The XEQ-3 electronic crossover/equalizer is intended primarily for high-quality sound systems which require precise crossover filtering and accurate speaker system compensation for optimum frequency and time response. The XEQ-3 incorporates fourth-order Linkwitz-Riley frequency-dividing networks which have two unique advantages over the third-order Butterworth networks often used in high-performance professional sound systems. First, a fourth-order network offers an out-of-passband attenuation rate of 24 dB per octave, greater than the 18-dB-per-octave rate of a third-order network. This provides better protection of drivers from energy outside their frequency range, important in some applications. Second, the Linkwitz-Riley network has "zero lobing error," for smoother overall frequency response in the crossover region. This concept is treated in more detail in the section below.

Each output of the XEQ-3 has a variable time-delay equalizer which is capable of compensating for different speaker mounting positions and phase responses, so that proper acoustic summing will occur at the crossover frequencies. Each output also has an EQ section controlled by a plug-in module. The LOW EQ can be used as an infrasonic filter or for "step-down" operation of TL bass speaker systems. The MID EQ and HIGH EQ are designed to provide constant-directivity horn and driver equalization when used with the appropriate module. The XEQ-3 is supplied with an HP16/32 module (infrasonic filter at 16 or 32 Hz) for the LOW EQ and two EQF modules (flat response, no EQ) for the MID EQ and HIGH EQ sections. Other modules can be ordered from Electro-Voice or custom built using the supplied BMK blank module.

Other features include a level display for optimizing dynamic range; a level control, polarity reverse switch and mute switch for each output; switches which allow two-way crossover operation; and floating differential input and outputs. Output transformers (Electro-Voice TRB-2 set of three) can be installed if desired.

The XEQ-3 mounts in one EIA rack space and is supplied with a smoked acrylic front cover to prevent uninvited control adjustment. Figure 2 shows the XEQ-3 block diagram.

LINKWITZ-RILEY NETWORKS AND "ZERO LOBING ERROR"

Linkwitz-Riley networks have zero lobing error because their outputs are (1) in phase in the crossover region and (2) 6 dB down at the crossover frequency. (The outputs of a third-order Butterworth network are 90° apart and 3 dB down at the crossover frequency.)

The acoustic consequences of zero lobing error can be appreciated by considering a two-way speaker system. For simplicity, assume that the sound from each transducer radiates from exactly the same vertical plane, i.e., the drivers have no time delay with respect to each other. Under these conditions:

1. A Linkwitz-Riley network promotes smoother overall frequency response in the crossover region, considering observation points both on and off the system axis. Frequency response is flat on the system axis and there are no off-axis response peaks. In contrast, when a third-order Butterworth network provides flat response on axis, a 3-dB peak must appear off axis, at that angle where the time delay due to different distances from the listener puts the two transducer outputs exactly in phase.
2. A Linkwitz-Riley network places the inevitable interference dips (due to two transducers providing output in the same frequency range) symmetrically above and below the system axis. The lobe in between is aimed along the system axis. In contrast, a third-order Butterworth network aims the lobe at some angle relative to the system axis, a consequence of the 90 phase difference between the outputs of the network. The angle of the lobe is the location of the Butterworth response peak described above.

A more detailed and graphic treatment of the subject is available in a number of technical articles, including:

1. S.H. Linkwitz, "Active Crossover Networks for Noncoincident Drivers," J. Audio Eng. Soc., vol. 24, pp. 2-8 (1976 January/February).
2. S.P. Lipshitz and J. Vanderkooy, "A Family of Linear-Phase Crossover Networks of High Slope Derived by Time Delay," J. Audio Eng. Soc., vol. 31, pp. 2-20 (1983 January/February).

CONNECTIONS

Input and Outputs

The input connector is a 3-pin female XLR type; output connectors are 3-pin male XLR type. Pins 2 and 3 are signal and each pin 1 is connected through a 10-ohm resistor to chassis ground. This grounding arrangement works well in most installations; pin 1 can be used as a ground reference or, if there is another reference (a ground loop is formed), then the resistor allows pin 1 to follow the other ground reference. A solid chassis ground connection can be obtained at the connector shell.

The floating differential input and outputs can be unbalanced and referenced to other equipment, or they can be connected to balanced lines. If a true balanced source (or load) is needed, connect a 300-ohm resistor from pin 2 to pin 1 and another 300-ohm resistor from pin 3 to pin 1.

Low Mix

The low-mix (or "common-bass") connection is an RCA phono jack which allows the low output to be mixed with the low output of another XEQ-3 or XEQ-2. This can improve the performance of stereo or multi-channel installations by equally distributing low-frequency energy among the low-frequency speakers. The low-mix connection also allows the use of a single amplifier/subwoofer combination in stereo or multi-channel systems.

Any number of crossovers may be used this way by connecting their low-mix jacks together. When XEQ's are interconnected in the low-mix mode, any or all of the low-frequency outputs may be used. These outputs will have a common signal but their individual level, polarity, mute and delay controls will still function independently.

Power

A green LED on the front panel indicates when ac power is ON. The XEQ-3 may be left on indefinitely or externally switched with other equipment.

EQUALIZATION SECTIONS

Low-Frequency Equalization

The LOW EQ socket accepts plug-in modules for different types of high-pass filters. The HP16/32 module (supplied) will provide a second-order Butterworth (maximally flat) response with a cutoff frequency of either 16 Hz or 32 Hz, depending on which number is right-side up when the module is installed. Other modules are available for "step-down" operation (low-frequency extension) of Electro-Voice TL bass speaker systems. The EB29/35 and EB45/60 provide 6 dB of boost at the corresponding peak frequencies, for this purpose. Modules can be constructed for other frequencies and high-pass filter types—see Custom Low-Frequency Modules section.

Mid- and High-Frequency Equalization

The MID EQ and HIGH EQ circuits are identical to each other, but are in the mid and high signal paths, respectively. These circuits will accurately equalize high-performance compression drivers used with constant-directivity horns. The proper EQ module for use with various EV horn-driver combinations is shown in Table 1.

For applications requiring flat electrical frequency response, use EQF modules. The XEQ-3 is supplied with EQF modules installed in the MID EQ and HIGH EQ sockets.

Model	Used With: Horn	Used With: Driver
EQA	HR90	DH101DA, DH1506
EQB	HR120, SM120	
EQC	HR40, HR60	
EQD	HR9040A,HR4020A	
EQE	HR6040A	
EQF	FLAT	
EQG	HR90	DH2012
EQH	HR120	
EQJ	HR40, HR60	
EQK	HR9040A,HR4020A	
EQL	HR6040A	
EQM	HP940	DH1, DH2
EQN	HP1240	
EQO	HP420, HP640	
EQP	HP9040, HP4020	
EQQ	HP640	
EQR	HP940	DH1A, DH2A
EQS	HP1240	
EQT	HP640	
EQU	HP4020, HP6040,HP9040	
EQV	HP420	
EQW	HP64, HP94	

CONTROL FUNCTIONS

Crossover Frequency

The six-position rotary switches select the frequencies for the low-mid and mid-high crossover filters. The corresponding outputs will be 6 dB down at the selected frequency, compared to the midband response. See Figure 3.

The XEQ-3 can be modified to provide other frequencies—see Non-Standard Crossover Frequencies section.

Input Level Indicator

The level of the input signal to the XEQ-3 is monitored with three LED's. The green LED indicates signal above 20 dBu, and the yellow LED lights when the signal reaches 0 dBu. The red LED lights if the input or any output exceeds +16 dBu. In normal operation, the yellow LED should light much of the time (indicating normal

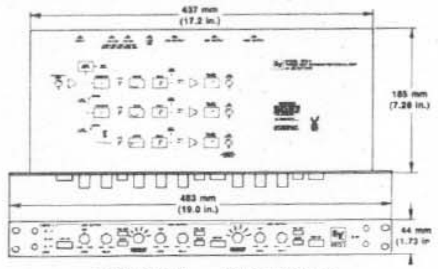


FIGURE 1 — Dimensions

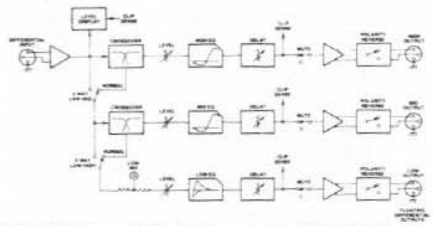


FIGURE 2 — XEQ-3 Crossover Block Diagram

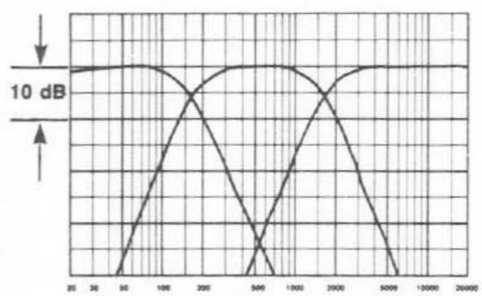


FIGURE 3 — Typical Crossover Curve

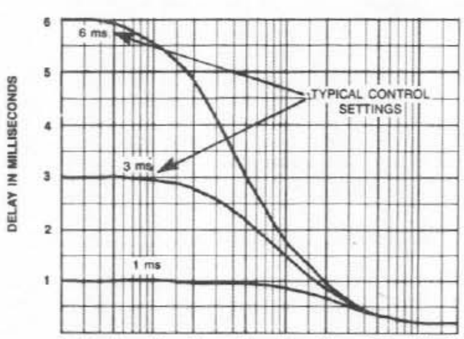


FIGURE 4 — Low-Frequency Time Delay

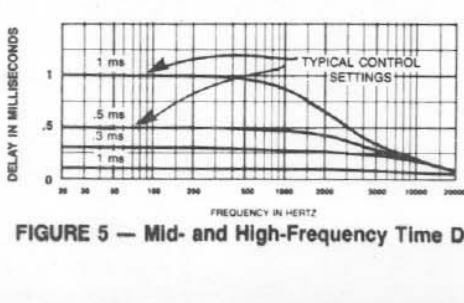


FIGURE 5 — Mid- and High-Frequency Time Delay

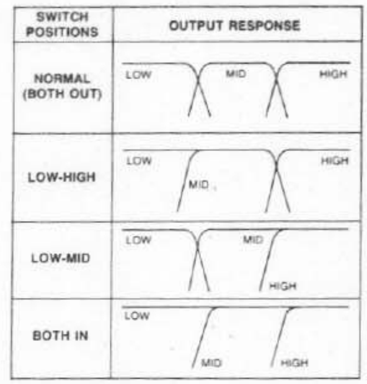


FIGURE 6 — Switching for Two-Way Operation

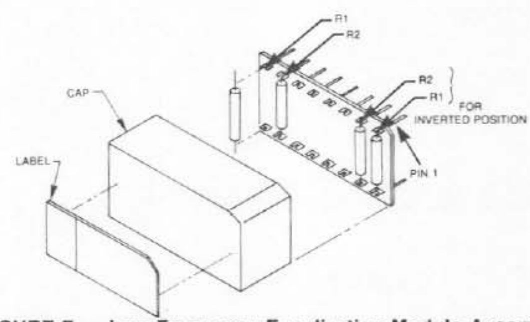


FIGURE 7 — Low-Frequency Equalization Module Assembly

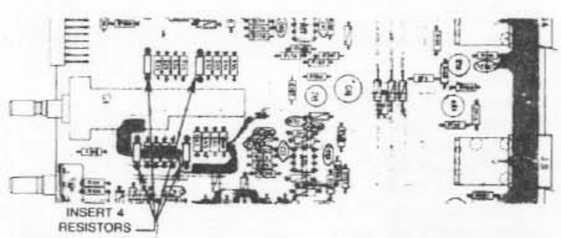


FIGURE 8 — Crossover-Frequency Modification

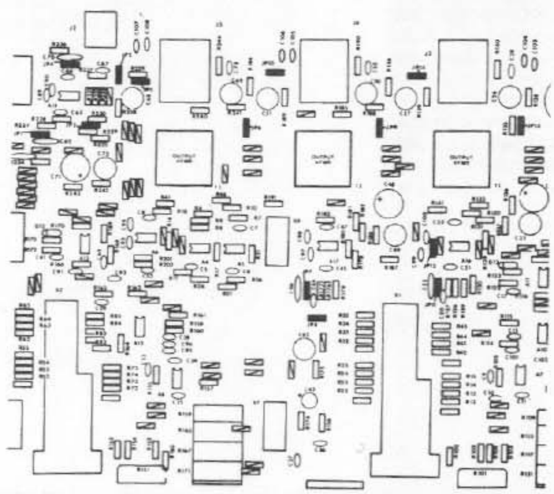


FIGURE 9 — Transformer Mounting Locations. Jumpers to Cut are Shown as Solid Rectangles.

Time-Delay Controls
Each output on the XEQ-3 has a time-delay control which allows compensation for the time- and phase-response differences which exist in almost all practical multi-way speaker setups. The delay sections are four-pole, all-pass filters with continuously variable time constants (see Figures 4 and 5). Adjusting a delay control is acoustically equivalent to physically moving the corresponding speaker with respect to the others. The delays available may not always be sufficient to compensate for all physical location differences encountered. However, half-wave-length shifts should nearly always be possible, thus eliminating the interference cancellations that can occur at crossover.

Normally only two delay controls are needed in a particular setup; the speaker with its acoustic center furthest from the listener should have its delay control left at "0." There may be exceptions to this, such as when a certain unusual time response is desired. The best way to adjust these controls is by measuring the direct-field on-axis frequency response using a plotter or a spectrum analyzer: reverse the polarity of the output to be adjusted, turn the delay control until the deepest possible response null occurs at the crossover frequency, then restore the correct polarity. The result will be optimum phase and frequency response through the crossover region. The delay controls can also be adjusted with just an oscillator, set at the crossover frequency, by listening for and adjusting for the null, on axis and in the speaker system's direct sound field. Switching to the correct polarity will then yield flat response. Set the level controls first, then set the delay controls.

Two-Way Operation
The XEQ-3 can easily be set up for two-way operation by pressing one of the switches on the back panel. Which switch to press (LOW-MID or LOW-HIGH) depends on which crossover frequency range is needed. The two corresponding outputs are then used. The third output can be used also, if another speaker in a stack or cluster needs a different equalization module or control setting. For example, by pressing LOW-MID and setting both crossover frequency switches to 500 Hz or 800 Hz, the mid and high outputs have the same frequency range but separate controls and EQ. The possible combinations are shown in Figure 6.

CUSTOM LOW-FREQUENCY MODULES

High-Pass Filters
If a low-frequency cutoff other than 16 Hz or 32 Hz is needed, a module can be constructed for other frequencies by soldering resistors into the supplied BMK blank module kit. Two resistors are needed for each filter frequency. Note that each module can accommodate two frequencies since there are two ways to plug it into the socket. One-quarter-watt film resistors having a resistance tolerance of 1% or 2% are recommended, but in less critical applications, 5% resistors may suffice. Mil-type RN55D resistors are easiest to use; however, con formally coated resistors may also be used. In the following formulas, R_1 and R_2 are in ohms, and f_3 is the corner frequency in Hz:

$$R_1 = \frac{1.06 \times 10^{13}}{4.7 \times 10^6 \times f_3 - 2.25 \times 10^5}$$

$$R_2 = \frac{R_1 \times 4.7 \times 10^6}{2 \times R_1 + 9.4 \times 10^6}$$

For maximally extended low-frequency response, use R_1 = 1 megohm and leave R_2 out. The f_3 will then be around 5 Hz to 10 Hz, depending on the load impedance.

Step-Down EQ Modules
To make modules for step-down equalization of low-frequency speaker systems, use the following formulas. The equalization circuit will produce a 6-dB peak at the frequency f_p and a 12-dB-per-octave rolloff below the peak:

$$R_1 = \frac{3.11 \times 10^{13}}{4.7 \times 10^6 \times f_p - 6.61 \times 10^6}$$

$$R_2 = \frac{4.43 \times 10^5}{f_p}$$

Module Construction
In addition to the Electro-Voice BMK blank module kit, the following items are required:

1. Two or four resistors, calculated from the formulas given above.
2. Low-wattage soldering iron with small chisel tip.
3. Electronic-grade solder, 63/37 or 60/40 alloy, rosin core.
4. Flush-cutting diagonal cutters.
5. A spare 16-pin DIP socket.
6. Adhesive: epoxy, super glue or hot melt.
7. Various hand tools, as needed.

Refer to the diagram in Figure 7:

1. Insert the DIP plug into the spare socket or use the one on the XEQ-3. This helps to keep the pins in alignment during soldering.
2. Locate pin 1 by the cut-off corner on the plug.
3. Place and solder the resistors one by one and trim each lead close enough to the pin to allow later installation of the cap. If you are using conformally coated (dipped) resistors, be sure the leads are free of the coating material where they emerge from the resistor body. Be careful not to overheat the pins, or the plastic base will melt.
4. Check all connections and resistor values.
5. Attach the cap with glue.
6. Label the module.

NON-STANDARD CROSSOVER FREQUENCIES

The XEQ-3 can be modified to provide crossover frequencies other than the six frequencies available at each switch. This is easily done (only resistors and a phillips screwdriver are needed) if the new crossover frequency is between 80 Hz and 800 Hz for the low-mid switch and between 500 Hz and 8 kHz for the mid-high switch. Four ¼-watt, 1% resistors are needed for each filter switch. For a crossover frequency f_c, the following resistor value is needed:

1. Low-mid filter:

$$R = \frac{2.83 \times 10^{10} - 3.56 \times 10^7 \times f_c}{1.98 \times 10^4 \times f_c - 1.59 \times 10^6}$$

2. Mid-high filter:

$$R = \frac{4.79 \times 10^{11} - 6.02 \times 10^7 \times f_c}{3.21 \times 10^4 \times f_c - 1.59 \times 10^7}$$

Choose the nearest standard value. For each filter, all four resistors must be the same. Remove two screws from each side and the back of the XEQ-3 and lift off the cover. Near each rotary switch are lead sockets for the four resistors. Cut the resistor leads to about inch long, bend them at right angles, and insert them straight into the sockets. See Figure 8. The new crossover frequency will occur at the counterclockwise switch position; that position should be relabeled.

OUTPUT TRANSFORMERS

The outputs of the XEQ-3 can be transformer coupled by adding the optional TRB-2 set of three transformers to the circuit board. This should be done by a qualified service technician. Remove two screws from each side and the back, and lift off the top cover. Then remove the five screws holding the circuit board to the chassis, and four hex screws from the front panel. The circuit board, with the front panel attached, can then be removed from the chassis.

There are fourteen jumpers which must be removed from the board so that the three transformers will have the proper drive, feedback, and output connections. The jumpers are labeled JP1 through JP14. See Figure 9. To remove a jumper, clip the lead at each end and remove the center section.

The transformer lead layout is asymmetrical, so verify the orientation of the transformer leads with the holes in the circuit board before installing. Solder all connections on the foil side of the board. Reassemble the XEQ-3 in reverse order from the description above.

WARRANTY (Limited)

Electro-Voice Professional Sound Reinforcement Electronic Components are guaranteed for two years from date of original purchase against malfunction due to defects in workmanship and materials. If such malfunction occurs, unit will be repaired or replaced (at our option) without charge for materials or labor if delivered prepaid to the proper Electro-Voice service facility. Unit will be returned prepaid. Warranty does not extend to finish, appearance items or malfunction due to abuse or operation under other than specified conditions, nor does it extend to incidental or consequential damages. Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above exclusion may not apply to you. Repair by other than Electro- Voice or its authorized service agencies will void this guarantee. A list of authorized service centers is available from Electro-Voice, Inc., 600 Cecil Street, Buchanan, MI 49107 (AC/616-695-6831); or Electro-Voice West, 8234 Doe Avenue, Visalia, CA 93291 (AC/209-651-7777). This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.
Service and repair address for this product: Electro-Voice, Inc., 600 Cecil Street, Buchanan, Michigan 49107. Phone: 616/695-6831.

Specifications subject to change without notice.

Part Number 531724—113

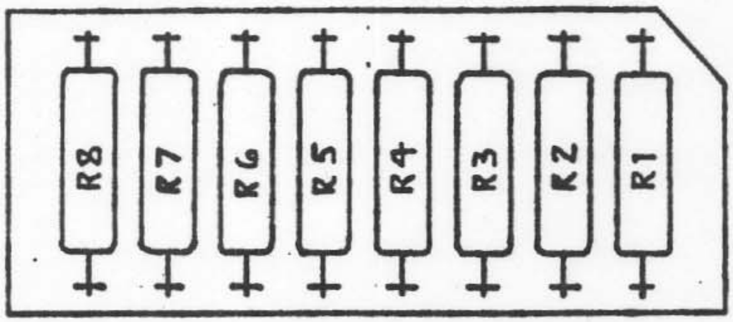
ELECTRO-VOICE, INC., 600 Cecil Street, Buchanan, Michigan 49107
MANUFACTURING PLANTS AT ■ BUCHANAN, MI ■ NEWPORT, TN ■ SEVIERVILLE, TN ■ OKLAHOMA CITY, OK ■ GANANOQUE, ONT.

■ Litho in U.S.A.
Part Number 531724—109
a MARK IV company

EQ MODULES FOR XEQ-3

MODULE	POS.1	POS.2	POS.3	POS.4	POS.5	POS.6	POS.7	POS.8
EQ A	--	--	68.1K	48.7K	4.75K	--	56.2K	26.1K
EQ B	--	--	100K	48.7K	4.75K	--	68.1K	19.1K
EQ C	--	--	100K	48.7K	4.75K	--	100K	22.1K
EQ D	--	--	100K	39.2K	3.92K	--	100K	48.7K
EQ E	--	--	100K	39.2K	3.92K	--	147K	48.7K
EQ F	--	SHORT	--	--	--	--	SHORT	--
EQ G	--	1.00M	100K	9.53K	.825K	--	140K	47.5K
EQ H	--	1.00M	100K	15.0K	2.32K	--	68.1K	30.1K
EQ J	--	1.00M	100K	22.1K	2.32K	--	100K	23.7K
EQ K	--	1.00M	100K	7.50K	5.62K	--	110K	51.1K
EQ L	--	1.00M	100K	7.50K	5.62K	--	110K	51.1K
EQ M	--	--	140K	.392K	12.7K	--	158K	20.5K
EQ N	--	--	41.2K	8.45K	1.37K	--	169K	41.2K
EQ O	--	--	SHORT	28.7K	2.00K	--	78.7K	78.7K
EQ P	--	--	53.6K	41.2K	3.01K	--	53.6K	28.7K
EQ Q	--	--	41.2K	37.4K	4.75K	--	47.5K	41.2K
EQ R	--	--	100K	16.9K	SHORT	--	107K	40.2K
EQ S	--	--	100K	3.57K	1.82K	--	107K	40.2K
EQ T	--	--	84.5K	13.3K	1.43K	--	86.6K	66.5K
EQ U	--	--	35.7[illegible]	14.3K	5.62K	--	14.7K	SHORT
EQ V	--	--	84.5K	13.3K	3.16K	--	86.6K	28.0K

XEQ-3 HF/MB Horn/Driver EQ Modules



HF Boost:

More Boost: Decrease R3
Less Boost: Increase R3

Higher Freq: Decrease R4 & R5
Lower Freq: Increase R4 & R5

MF Dip:

More Cut: Increase R7, Decrease R8
Less Cut: Decrease R7, Increase R8

Higher Freq: Decrease R7 & R8
Lower Freq: Increase R7 & R8

Note: Adding a 1.0 MΩ resistor in the R2 position (in place of the open circuit) will slightly decrease the "Q" of both the HF Boost and the MF Dip.

Typical Resistor Values for EV Drivers and Horns:

Resistor	DH1A,DH2A,N/Dym-1 on Small CD Horns	DH1A,DH2A,N/Dym-1 on Large CD Horns	DL10Xon Phase Plug on MB Horns
R1	Open	Open	Open
R2	Open or 1MΩ	Open or 1MΩ	Open or 1MΩ
R3	75k-125kΩ	20k-60kΩ	30k-70kΩ
R4	3k-20kΩ	3k-20kΩ	3k-20kΩ
R5	0-10kΩ	0-10kΩ	0-10kΩ
R6	Open	Open	Open
R7	75k-100kΩ	5k-20kΩ	400k-1MΩ
R8	25k-75kΩ	0-10kΩ	150k-500kΩ