# Symetrix

## 524E

Multi-mode Electronic

Crossover

# Owner's Manual

Signal Processing at it's Best!

Revision: 1.0, 3/16/93
Subject to change at our whim, and without notice.
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Part number: 530200

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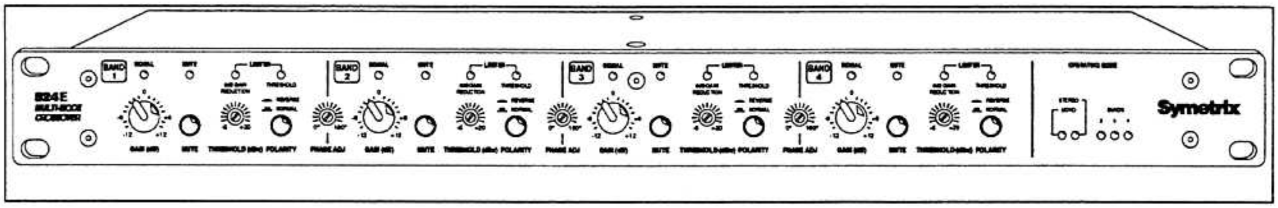


# 1. Introduction

The Symetrix 524E is a high-performance multi-mode crossover/speaker processor. The 524E can be used in stereo two-way and mono three- and four-way systems. But wait...there's more! Not only will the 524E slice your input signal into as many as four bands, it will also protect those expensive transducers from overload and it allows optimizing driver alignment.

In today's state-of-the art audio systems, the system crossover must now do more than simply slice and dice the audio signal into discrete frequency bands. Driver alignment, driver protection, CD horn EQ, LF tailoring are all parameters that the modern system crossover now must provide.

We recommend that you read this manual from cover to cover. Somewhere between the confines of the two covers you should find the answers to most (98%) of your questions, both technical as well as musical.

If you're in a hurry (like most of us), or if you really don't believe that someone could write a decent owners manual that you can read and understand, then do us both a favor and read section 6, "Fast First Time Setup." This section will help you get connected, tell you what the knobs do, and send you on your way.

## 1.1 Manual Sections

This manual contains the following sections:

Section 1, *Introduction*, introduces the 524E and this manual.

Section 2, *Crossover Basics*, lets you know what the 524 does, and how it does it.

Section 3, *Technical Tutorial*, covers signal levels, input and output impedances, and connection polarity.

Section 4, *Front Panel Overview*, offers a brief look at the controls and switches of the 524E.

Section 5, *Rear Panel Overview*, offers brief look at the connectors and rear panel of the 524E.

Section 6, *Fast, First Time Setup*, is a section written especially for people who just can't wait to get their hands on the knobs.

Section 7, *Using the 524E*, describes the use of the 524E in detail.

Section 8. *Applications*, describes a few special hookups for the 524E.

Section 9, *Troubleshooting*, tells what to do if the 524E doesn't work.

Section 10, *Limited Warranty*, describes the 524E's warranty.

Section 11. *Repair Information*, tells how to get your 524E repaired.

Section 12. *Specifications*, lists the technical specifications of the 524E's performance. The Architects and Engineer's specifications are found here too.

Section 13. *Service Information*, contains Printed Circuit Board Layouts and Schematic diagrams for the 524E.

Appendix A, *Crossover Frequency Card Stuff*, describes how to build your own crossover boards for the 524E.

Appendix B, *Bypass Card Programming*, tells how to build a bypass card.

Appendix C, *Disassembly Instructions*, tells how to disassemble the 524E.

Appendix D, *Bibliography*, lists a few related papers and publications that may be of interest.

## 1.2 Notational Conventions

Several notational conventions are used in this manual. Some paragraphs may use Note, Caution, or Warning as a heading. These headings have the following meaning:

| Convention | Description |
|---|---|
| Note | Identifies information that needs extra emphasis. A Note generally supplies extra information to help you use the 524E better. |
| Caution | Identifies information that, if not heeded, may cause damage to the 524E or other equipment in your system. |
| Warning | Identifies information that, if ignored, may be hazardous to your health or that of others. |

In addition, certain typefaces and capitalization are used to identify certain words. These situations are:

| Convention | Meaning |
|---|---|
| CAPITALS | Controls, switches or other markings on the chassis. |
| Boldface | Strong emphasis. |

# 2. Crossover Basics

A crossover is nothing more than a collection of high-pass and low-pass filters used to separate or split an incoming audio signal into discrete frequency bands. In audio systems, a crossover usually preceeds a multi-way loudspeaker system and ensures that each system component only receives frequencies it is capable of reproducing.

A high-level crossover connects between the power amplifier and speaker system. A low-level crossover connects before the power amplifier(s); thus there must be at least one power amplifier per crossover output. This technique is known as bi- or tri- or multi-amplification. The benefits are well known; increased headroom, increased peak level capability, and freedom from intermodulation distortion, among others. Multi-amplification is the rule for state-of-the-art sound systems.

The Symetrix 524E is the combination of 24 dB/octave crossovers 24 dB/octave high-pass filters peak limiters, driver alignment delays, and constant-directivity horn equalizers. We'll take a few moments to discuss each of these features.

## 2.1 Linkwitz Riley Crossovers

Crossovers are made from high- and low-pass filters. An inescapable bit of math and physics says that if these filters affect amplitude, they will also affect phase. Herein lies the rub. An important part of a crossover's performance is the quality with which two adjacent outputs (with respect to frequency) recombine. Ideally, the two outputs would recombine perfectly, resulting in flat frequency response through the transition region, that is, the region where both outputs contribute to the whole (the outputs always overlap in the transition region because they don't have infinite-slope (brick-wall) skirts).

Unfortunately, the world is far from ideal, and crossovers are no exception. Finding a crossover configuration whose outputs recombine perfectly has been the subject of much research. The problem is: 6 dB/octave crossovers (first-order) are the only configuration that recombines perfectly. Unfortunately, 6 dB/octave slopes result in far too much out-of-band energy through the driver for anything other than home hi-fi.

The next step was to increase the slope, to 12 dB/octave (second-order). With each increase in slope comes a new set of problems, caused by the phase relationships between the two outputs. In a second-order crossover, the two outputs are out-of-phase with each other at the crossover frequency, thus the sum of the two outputs is an infinite notch at the crossover frequency. Fortunately, most loudspeakers don't recombine that perfectly, so the notch was minimized, but still there.

18 dB/octave crossovers bring their own problems to the party, and so on. (We're trying to make this the severely abridged, Readers Digest version of crossover history.) One matter that has been completely unaddressed is that of radiation angle. A by-product of the phase shift problem is a position sensitive lobe (or peak) in the polar pattern of the resultant system. The lobe varies in position, quantity, and angle with the type of crossover (slope, filter type, etc.), the drivers, their center-to-center spacing, as well as their time offset.

In 1976, Siegfried Linkwitz published a paper in the Journal of the Audio Engineering Society (JAES) called "Active Crossover Networks for Noncoincident Drivers." This landmark paper describes all of the problems previously described, introduces the radiation angle problem, and (aha!) presents a simple solution. Mr Linkwitz wanted a crossover that would recombine, and allow correcting for the time offset of his drivers (he originally did this work for his home hi-fi). After a lot of math, he derived a class of filters having the following characteristics:

1. Zero phase difference between the drive signals at the crossover frequency. This avoids tilting in the radiation pattern.

2. The output of each filter must be -6 dB (usually it's -3 dB) at the crossover point, which forces a unity sum of the two outputs, and no peaking as a result.

3. The phase difference of the two drive signals must be the same for all frequencies to preserve the symmetry of the radiation pattern above and below the crossover frequency.

R. Riley (presumably a friend of Mr. Linkwitz) pointed out that the simple cascade of two second-order Butterworth filters would fulfill the above requirements; thus the origin of the crossover's name. Figure 2-1 shows the frequency response of several crossovers, each having different slopes.

## 2.2 Limiters

It has always been a good idea to put a limiter at the output of a crossover for the purpose of driver protection. In the past, few have actually done so, probably because of the cost and complexity involved. Many touring systems simply use an overall compressor-limiter at the crossover inputs and an overt threat of violence to guard against ignorance, incompetence, unwillingness, or human error on the part of the mixing engineer.

Although an overall limiter will protect your system, it will not allow pushing the performance envelope much. Generally, the loudest component of the mix controls the limiter, and if that is the bass and kick-drum, then the whole mix tends to suck and breathe in time with the kick/bass combination. Moving the limiters to the individual crossover outputs is the next logical step.

With limiters at the crossover outputs, you now have several options in the protection of your sound system. You can:

- ❒ set the limiter against an arbitrary SPL limit.
- ❒ set the limiter to keep the amplifier from clipping.
- ❒ set the limiter to keep from overpowering the loudspeaker.
- ❒ pick any combination of the above.

A mult-limiter protected system subtly changes the cues that you must listen for to know that you're at the system's limits. Previously, you listened for amplifier clipping, or for the sucking and breathing caused by the overall compressor-limiter. Now you must listen for spectral shift, which is caused by one output of the crossover going into hard limiting. The frequency balance of the sound system changes because the frequency band that went into limiting doesn't get any louder. Still, this is preferable to the sound of amplifier(s) clipping.

The attack and release time of the 524E's limiters is programmed via resistors on the crossover programming board. You are free to modify these time constants to suit your own preferences.

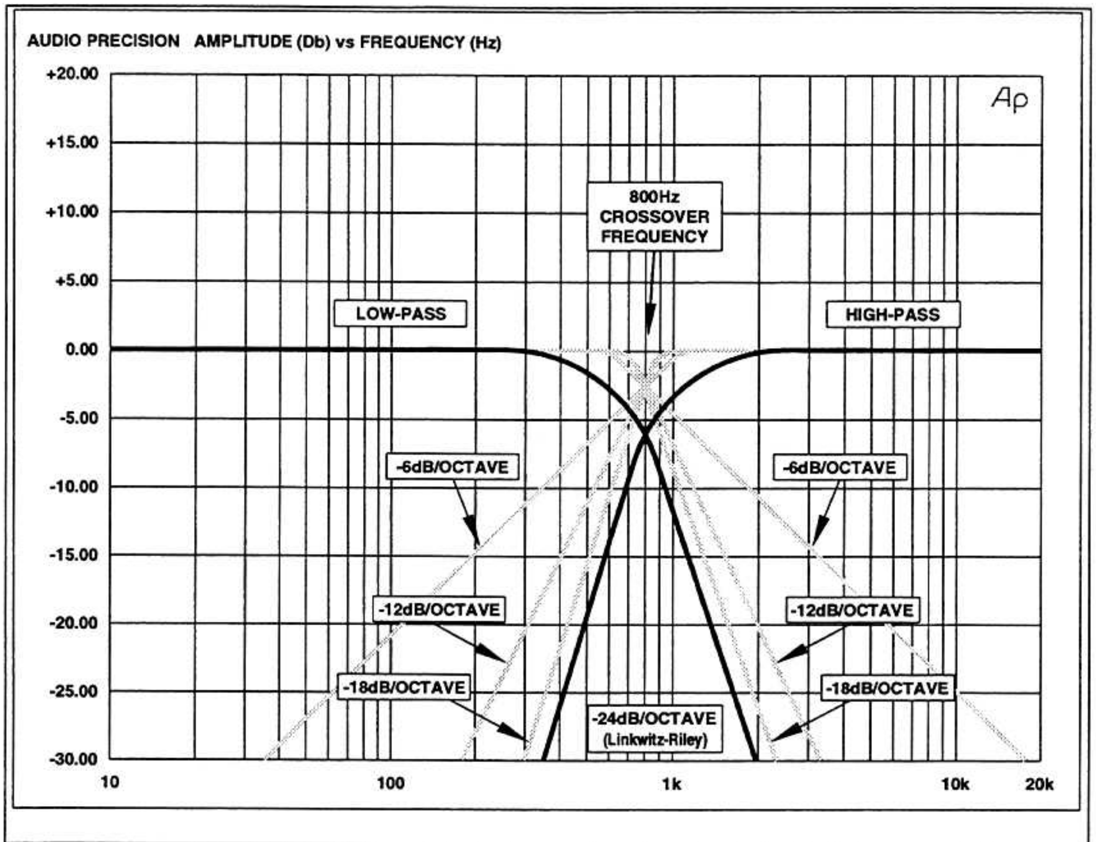
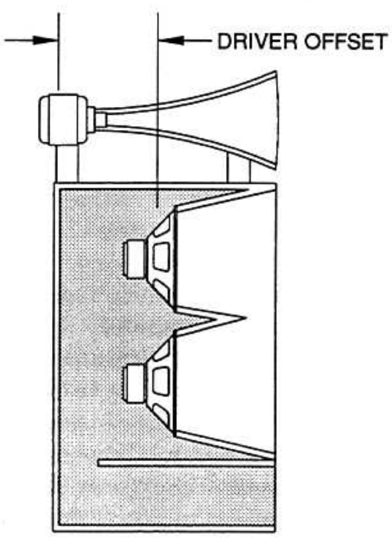



**Figure 2-1. Four different crossovers. Note that the Linkwitz-Riley curves cross at -6 dB vs -3 dB for the others.**

## 2.3 Driver Alignment

In most sound reinforcement systems, the drivers for different frequency ranges are usually not in vertical alignment with each other. This causes arrival time differences in the crossover region(s) because the different components of a waveform are "launched" into the air at the same time, but displaced from each other.




The Linkwitz-Riley crossover allows correcting for driver misalignment via simple phase delay. In the 524E, analog phase-shift networks provide up to 3 mS delay (at low frequencies) to compensate for driver placement. Since sound travels at about 1100 ft/sec in air, this amounts to about 3.3 feet of possible driver alignment correction.

The 524E design assumes that the VHF components of the system will be farthest from the listener, and therefore require no correction (since we can't go ahead in time---yet). The phase delay circuitry affects each band below the highest one, except in two-way mode. In two-way mode, the phase shifters affect the low-frequency output(s). For systems that do not adhere to this model, you can use a multi-output digital delay connected to the band-insert jacks of the 524E

For every crossover frequency, there is a unique value for the delay programming capacitor that is installed on the crossover programming board. See Section 7.4 and Appendix A for additional details.

## 2.4 Crossover Frequency Selection Considerations

The crossover frequency chosen for your system should be based on the following criteria:

1. System design
2. Loudspeaker limitations

Specifically excluded are personal preference and venue acoustics. The crossover frequency chosen should:

1. minimize loudspeaker operation below the driver's low-frequency cutoff
2. minimize operation in non-linear regions
3. consider cutoffs of pattern-control devices (horns)
4. consider the polar patterns of the two transducers in the crossover region

The crossover frequency of the 524E is specified by the buyer at order-time. The crossover programming circuit boards contain all of the frequency-determining components.

## 2.5 Low Frequency (subsonic) Filter

In most professional sound systems, the low-frequency bands are handled by direct radiating speakers. Sometimes these speakers are horn loaded and the enclosures usually are ported to improve bass efficiency. In either case, it is a waste of power to attempt to obtain substantial output below the box-tuning frequency. (Ported systems roll off at 24 dB/octave below the box resonance.) Trying to obtain output below the box-tuning frequency wastes amplifier power and invites early speaker failure.

The 524E has a 24 dB/octave high-pass filter connected at its input. Two resistor networks located on the main PCB adjust the cutoff frequency.

## 2.6 Constant-Directivity Horn EQ

The constant-directivity horns used with today's sound systems are truly wonderful devices. They all have one drawback: they all require equalization to correct for the falling power response of the compression driver.

All compression drivers exhibit a 6 dB/octave rolloff above about 3300 Hz. This is the mass rolloff caused by the inability of the electromagnetic system (voice coil + magnetic system) to move the mass of the diaphragm at higher frequencies. Figure 2-2 shows the frequency response of a 2-inch exit compression driver mounted on a plane-wave tube (PWT, a long, closed, tube stuffed with absorptive material such that there are no reflections within). Oddly (or is it?), the physics of compression drivers cause this rolloff to occur at approximately the same frequency, regardless of the size of the diaphragm or the diaphragm material. This is true as long as the driver falls in the 117-118 dB/1 mW (PWT) sensitivity class.

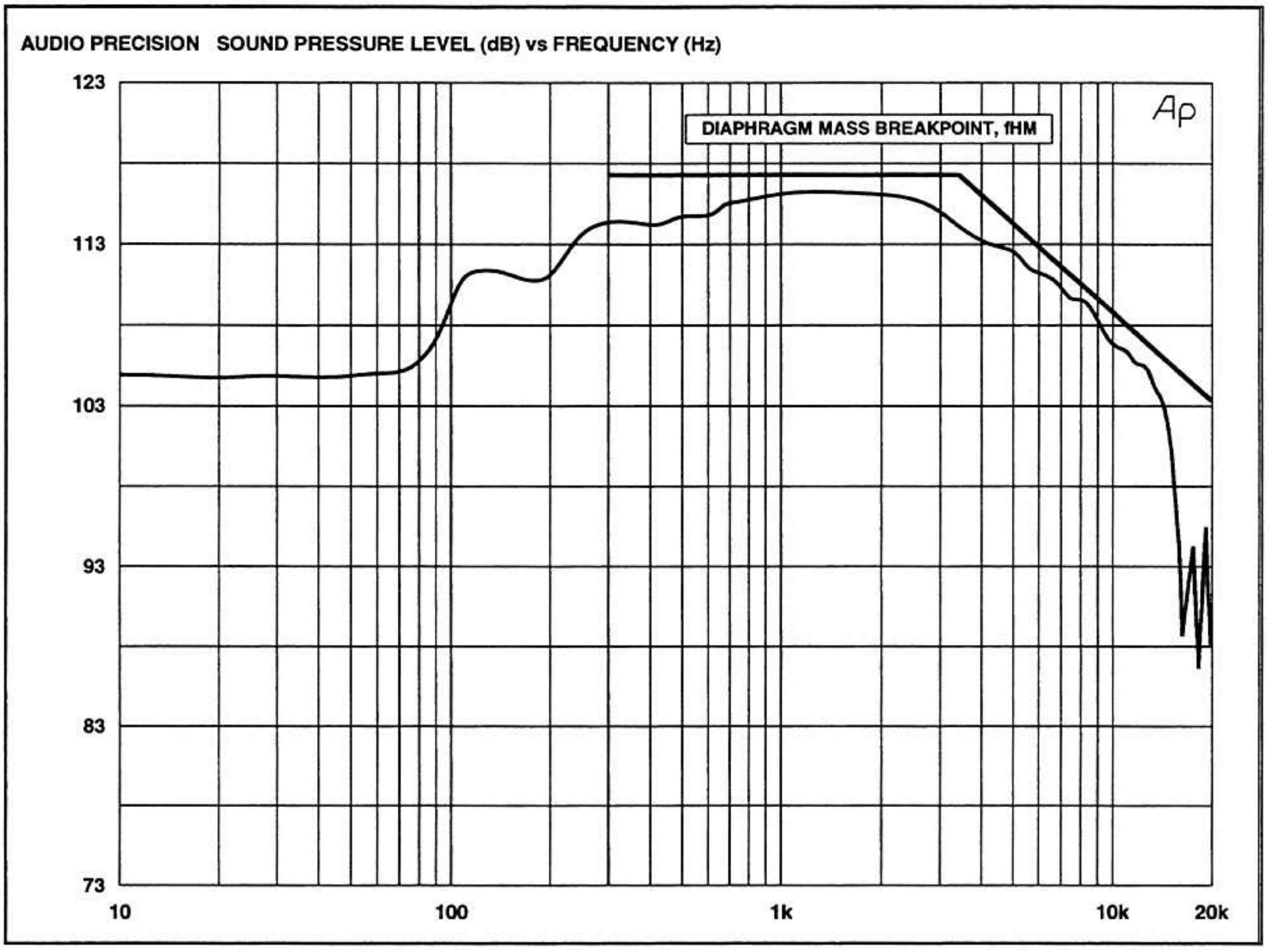



**Figure 2-2. The plane wave tube response curve (SPL vs frequency) of a typical 2-inch throat compression driver.**

Older radial and sectoral horns have narrowing dispersion patterns at higher frequencies. If you make the right design tradeoffs, you can make the horn pattern narrow at the same rate that the driver's response falls, and have flat response on-axis. So now we equalize the off-axis response to flat and we're done, right? Nope. Now we're flat off-axis, and on-axis we have a death-ray-beam of high frequencies.

Since constant-directivity horns do not exhibit beamwidth narrowing with increasing frequency, their output merely reflects what is fed into them. If we hang a compression driver onto the horn, then the horn's acoustical output mimics the power response of the driver, including the mass rolloff. This is why ALL constant-directivity horns, regardless of manufacturer, require driver power response correction (read equalization or CD horn EQ) for flat frequency response.

You can add CD horn EQ to the 524E via its crossover programming boards. As with crossover frequency, CD horn EQ is specified by the buyer at the time of order. We recommend a 3 dB point of about 3500 Hz, with about 10 dB lift at 20 kHz. This is a good compromise between correcting for the drivers mass rolloff, while not being so agressive as to sound "electric."

# 3. Technical Tutorial

This section discusses a multitude of things, all related to getting signals in and out of the 524E.

## 3.1 Matching Levels vs Matching Impedances

In any audio equipment application, the question of "matching" inevitably comes up. Without digging a hole any deeper than absolutely necessary, we offer the following discussion to (hopefully) clarify your understanding of the subject.

Over the years, we have all had impedance matching pounded into our heads. This is important only for ancient audio systems, power amplifiers, and RF. Technically speaking, the reason is power transfer, which reaches a maximum when source and load are matched. Modern audio systems are voltage transmission systems and source and load matching is not only unnecessary, but undesirable as well.

- ❐ Ancient audio systems operate at 600 ohms (or some other impedance value), and must be matched, both at their inputs and at their outputs. Generally speaking, if you are dealing with equipment that uses vacuum tubes, or was designed prior to 1970, you should be concerned about matching. These units were designed when audio systems were based on maximum power transfer, hence the need for input/output matching.

- ❐ Power amplifiers are fussy because an abnormally low load impedance generally means a visit to the amp hospital. Thus, it's important to know what the total impedance of the pile of speakers connected to the amplifier really is.

- ❐ RF systems are matched because we really are concerned with maximum power transfer and with matching the impedance of the transmission line (keeps nasty things from happening). Video signals (composite, baseband, or otherwise) should be treated like RF.

Some folks seem to believe that balanced/unbalanced lines and impedances are related; or even worse that they are associated with a particular type of connector. Not so. Unbalanced signals are not necessarily high-impedance and balanced signals/lines are not necessarily low-impedance. Similarly, although 1/4 inch jacks are typically used for things like guitars (which are high-impedance and unbalanced), this does not predispose them to only this usage. After all, 1/4 inch jacks are sometimes used for loudspeakers, which are anything but high-impedance. Therefore, the presence of 3-pin XLR connectors should not be construed to mean that the input or output is low-impedance (or high-impedance). The same applies to 1/4 inch jacks.

So, what is really important? Signal level, and (to a much lesser degree), the impedance relation between an output (signal source) and the input that it connects to (signal receiver).

Signal level is very important. Mismatch causes either loss of headroom or loss of signal-to-noise ratio. Thus, microphone inputs should only see signals originating from a microphone, a direct (DI) box, or an output designated microphone-level output. Electrically, this is in the range of approximately -70 to -20 dBm. Line inputs should only see signals in the -10 to +24 dBm/dBu range. Guitars, high-impedance microphones, and many electronic keyboards do not qualify as line-level sources.

The impedance relation between outputs and inputs needs to be considered, but only in the following way:

Always make sure that a device's input impedance is higher than the output source impedance of the device that drives it.

Some manufacturers state a relatively high-impedance figure as the output impedance of their equipment. What they really mean is that this is the minimum load impedance that they would like their gear to see. In most cases, seeing a output impedance figure of 10,000 (10K) ohms or higher from modern equipment that requires power (batteries or AC) is an instance of this type of rating. If so, then the input impedance of the succeeding input must be equal to or greater than the output impedance of the driving device.

Symetrix equipment inputs are designed to bridge (be greater than 10 times the actual source impedance) the output of whatever device drives the input. Symetrix equipment outputs are designed to drive 600 ohm or higher loads (600 ohm loads are an archaic practice that won't go away). You don't need to terminate the output with a 600 ohm resistor if you aren't driving a 600 ohm load. If you don't understand the concept of termination, you probably don't need to anyway.

The two facts that you need to derive from this discussion are:

1. Match signal levels for best headroom and signal-to-noise ratio.
2. For audio, impedance matching is only needed for antique equipment and power amplifier outputs. In all other cases, ensure that your inputs bridge (are in the range of 2 to 200 times the output source impedance) your outputs.

## 3.2 Signal Levels

The 524E is designed around studio/professional line levels: +4 dBu or 1.23 volts. The unit is quiet enough to operate at lower signal levels such as those found in semi-pro or musical-instrument (MI) equipment (-10 dBu or 300 millivolts). Conversely, there is sufficient headroom to operate the 524E at +8 levels found in some broadcast applications. The signal level at the sidechain jacks is the same as that found at the input connectors (but the interface point is unbalanced).

## 3.3 I/O Impedances

The 524E is designed to interface into almost any recording studio or sound reinforcement application. This includes:

- 600 ohm systems where input and output impedances are matched.
- Unbalanced semi-professional equipment applications.
- Modern bridging systems where inputs bridge and outputs are low source impedances (voltage transmission systems).

The 524E's input impedance is 40 kilohms balanced, and 30 kilohms unbalanced. The inputs may be driven from any source (balanced or unbalanced) capable of delivering at least -10 dBu into the aforementioned impedances.

524E's pre-band insert jacks are unbalanced i/o points connected to a TRS phone jack. The tip connection is the return, the ring connection is the send. The output source impedance is 100 ohms, intended to drive a load of 600 ohms minimum. The receive input impedance is 10 kilohms, unbalanced. The gain between the input connectors and the insert-point is 0 dB.

The 524E's output impedance is 200 ohms balanced, 100 ohms unbalanced. The output line driver delivers +24 dBm balanced or +18 dBm unbalanced into 600 ohm loads. Bridging loads receive a slightly higher signal level.

## 3.4 Polarity Convention

The 524E uses the international standard polarity convention of pin 2 hot. Therefore:

| XLR | Tip-Ring-Sleeve | Signal |
|---|---|---|
| 1 | Sleeve | Ground |
| 2 | Tip | High |
| 3 | Ring | Low |

If your system uses balanced inputs and outputs, and uses the 524E this way, then the polarity convention is unimportant. If your system is both balanced and unbalanced, then you must pay attention to this, especially when going in and coming out through different connector types (like input on an XLR, output on a phone jack).

## 3.5 Input and Output Connections

Figure 3-1 illustrates how to connect the 524E to balanced and unbalanced sources and loads.

To operate the 524E from unbalanced sources, run a 2-conductor shielded cable (that's two conductors plus the shield) from the source to the 524E. At the source, connect the low/minus side to the shield, these connect to the source's ground; connect the high/plus side to the source's signal connection. At the 524E, the high/plus wire connects to pin 2, the low/minus wire connects to pin 3, and the shield (always) connects to pin 1. This is the preferred method as it makes best use of the 524E's balanced input (even though the source is unbalanced). The other alternative shown in Figure 4 converts the 524E's balanced input into an unbalanced input at the input connector. This works, but is more susceptible to hum and buzz than the preferred method. There is no level difference between either method.

You can drive unbalanced loads with the 524E's outputs by using the XLR connector with pin 3 left open. In an emergency (the show must go on), you can ground pin 3, but if you have the choice...leave it open. If you must ground pin 3, it is must be grounded at the 524E, rather than at the other end of the cable. The price, regardless of whether or not pin 3 is grounded is 6 dB less output level. This can easily be made up via the individual band-gain controls.

The 524E's pre-band insert jacks are unbalanced i/o points connected to a TRS phone jack. The tip connection is the return, the ring connection is the send (Soundcraft convention).

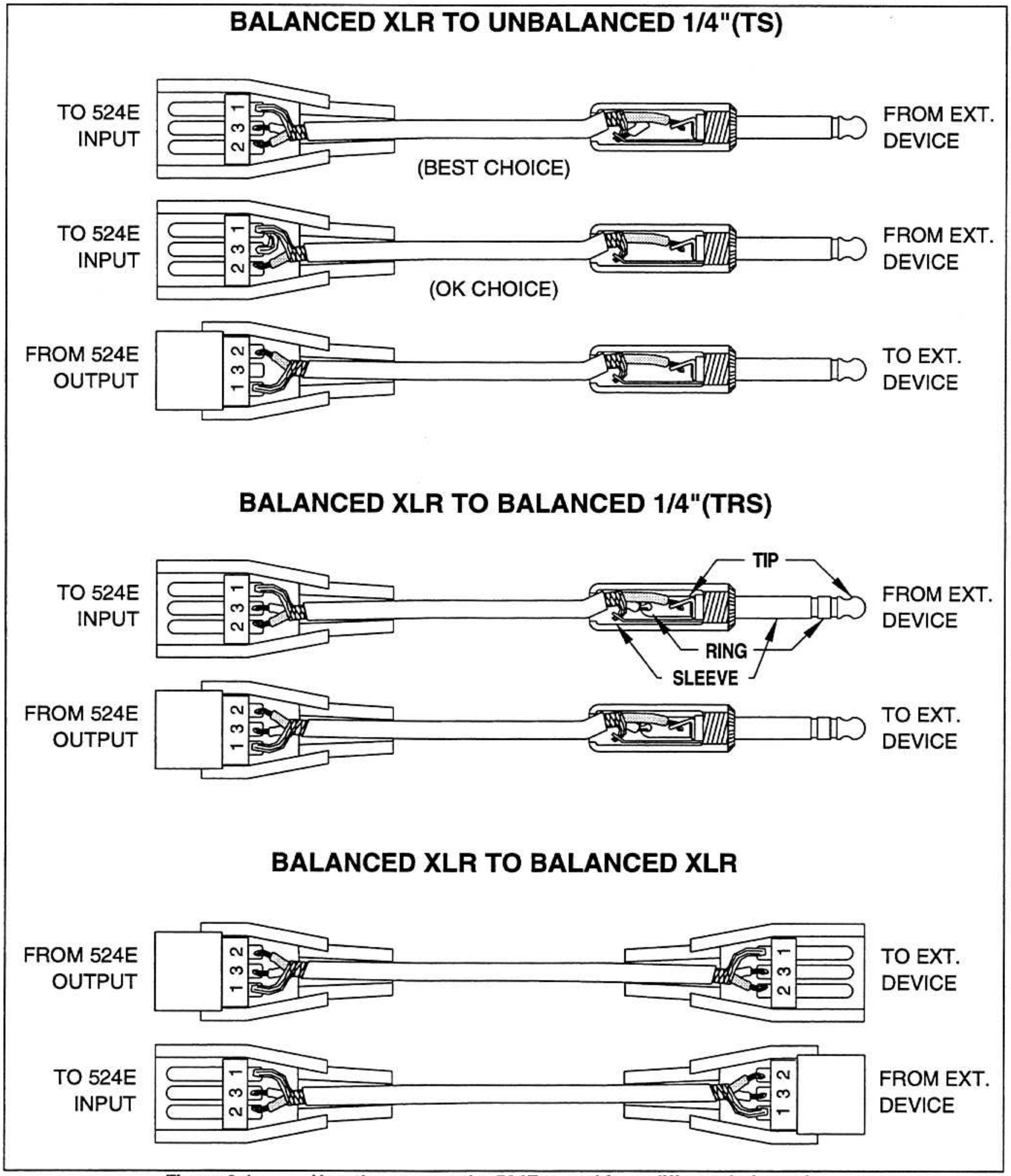
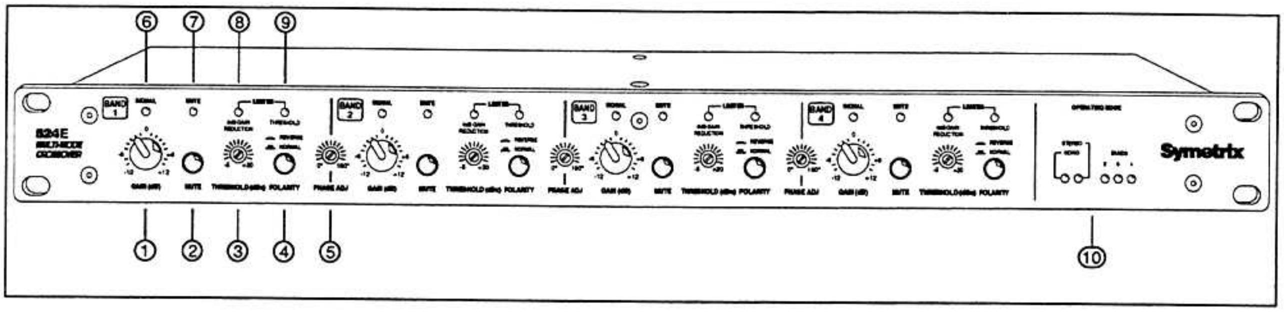



**Figure 3-1.** **How the connect the 524E to and from different balanced and unbalanced sources and loads.**

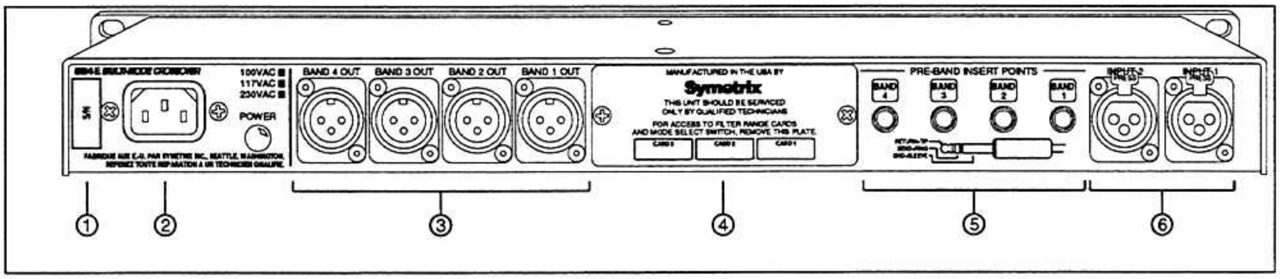
# 4. Front Panel Overview



Each band has identical controls, so we will only describe those for band 1.

| Ref | Control or Feature | Description |
|---|---|---|
| 1 | GAIN control | Adjusts the signal level at the output jack over a +/- 12 dB range. |
| 2 | MUTE switch | Push-on, push-off switch that mutes the output signal when depressed. |
| 3 | THRESHOLD control | Sets the threshold of the limiter for that output. |
| 4 | POLARITY switch | Inverts the polarity of the output signal when depressed. |
| 5 | PHASE ADJ control | Adjusts the phase of the output signal over a 180 degree range. |
| 6 | SIGNAL LED | Shows the presence of signal in that frequency band. |
| 7 | MUTE LED | Shows the status of the MUTE switch for that frequency band. |
| 8 | 6 dB REDUCTION LED | Indicates that the limiter has caused at least -6 dB of gain reduction. |
| 9 | THRESHOLD LED | Shows that the signal has exceeded the limiter threshold for that band. |
| 10 | MONO LED | Indicates that the 524E is operating in single-channel/mono mode. |
| 10 | STEREO LED | Indicates that the 524E is operating in two-channel/stereo mode. |
| 10 | BANDS LEDs | Indicate how many frequency bands the 524E has been set up for. |

# 5. Rear Panel Overview




| Ref | Item | Description |
|---|---|---|
| 1 | serial number | Do yourself a favor and write this number down in a safe place (how about the front of this manual?). While you're at it, do us a favor and return your completed warranty card. Not only does it establish your warranty, it helps give us a clue to your equipment wants, needs, and desires. |
| 2 | power connector | IEC power receptacle. Connect the power cord to an appropriate source of AC power. Observe the marked power supply voltage on rear panel. |
| 3 | individual band outputs | Four male XLR connectors. These are the outputs of the 524E. Their assignments are discussed later in this section. Each output is balanced, 200 ohm source impedance, +24 dBm maximum level (balanced). |
| 4 | access door | Removing the two phillips head screws allows removing this door to gain access to the mode-selector switch and the three crossover frequency cards. The mode switch settings (not to mention the switch itself) are found under this door. |
| 5 | insert jacks | Four TRS insert jacks. These jacks allow insertion of other signal processing on a per-band basis. The jacks are connected after the balanced input stage, but before the individual crossover filters. The signals present on these jacks is FULL-RANGE. This is an unbalanced insert point. Tip is return, Ring is send. Figure 5-1 shows most of the variations you are likely to encounter. |
| 6 | inputs | Two female XLR connectors. This is the 524E's balanced input. Input impedance is greater than 20 Kohms, maximum input level is +18 dBu. |

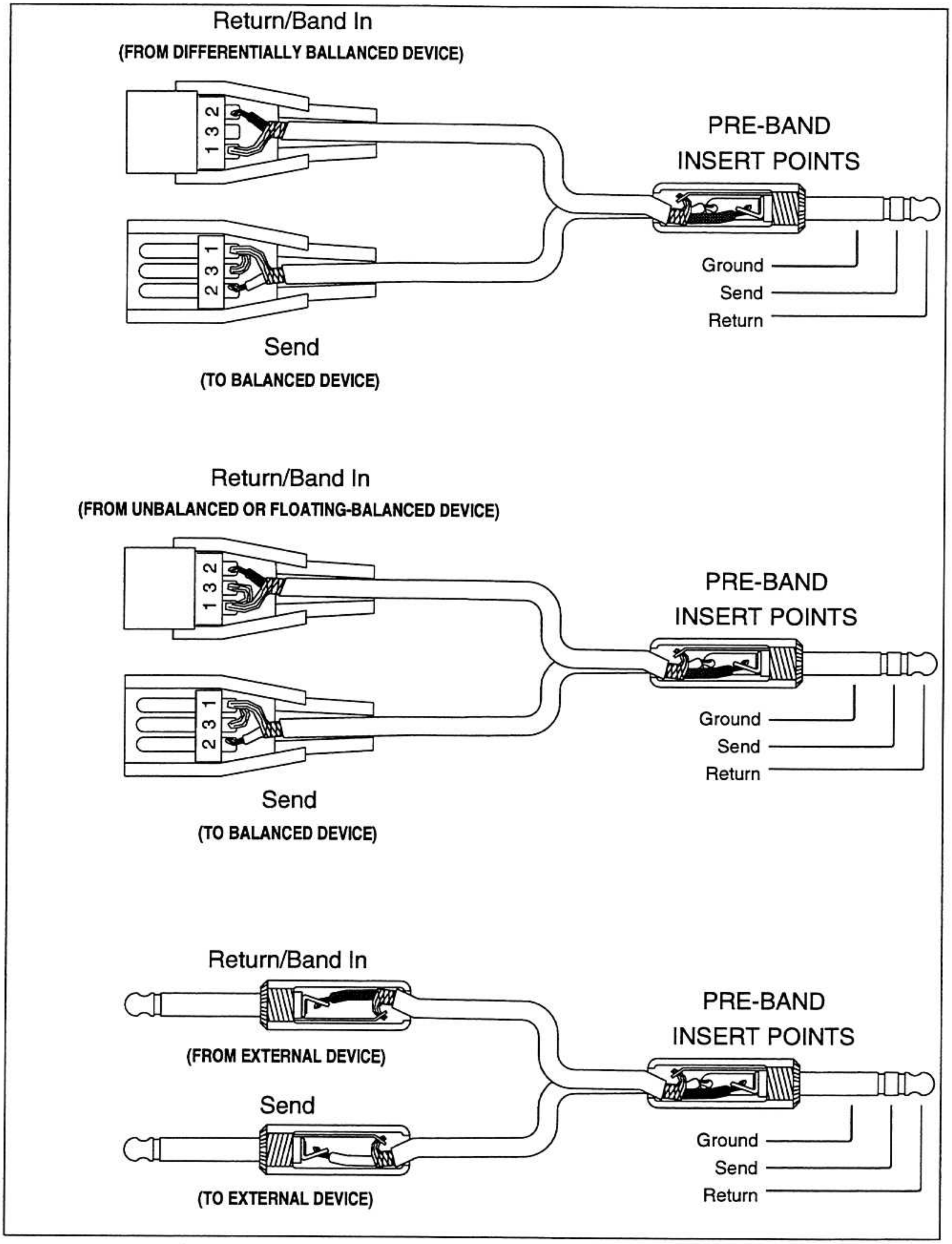
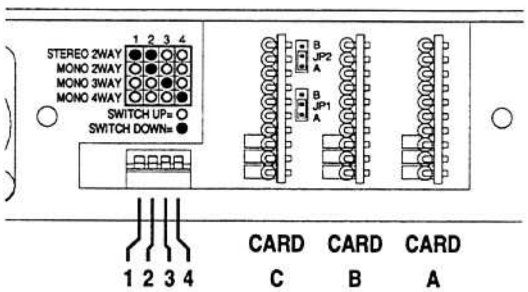



**Figure 5-1. Cable diagrams for connecting the 524E's PRE-BAND INSERT POINTS to external balanced and unbalanced devices.**

## 5.1 Configuration options

An internal DIP switch determines the configuration for the 524E. The switch is located to the left of the crossover module access hole located on the rear panel. The following figure and table show the switch settings and the crossover card locations.

| Mode | SW1 | SW2 | SW3 | SW4 | Notes |
|---|---|---|---|---|---|
| stereo 2-way | D | D | U | U | D = down<br>U = up |
| mono 2-way | U | D | U | U | |
| mono 3-way | U | U | D | U | |
| mono 4-way | U | U | U | D | |




In three-way mode, band 4 may be configured as an additional highpass or lowpass output. Jumpers JP1 and JP2 configure band 4 for this mode of operation. The jumpers are located on the crossover filter board motherboard, adjacent to crossover board B.

| Mode | JP1 | JP2 | Notes |
|---|---|---|---|
| All | A | A | 2-way & 4-way must be configured this way<br>3-way: augmented high-frequency |
| 3-way | A | B | not useful |
| 3-way | B | A | not useful |
| 3-way | B | B | band 4 used for subwoofers |

The band output connectors are assigned as follows:

| Mode | Band 1 | Band 2 | Band 3 | Band 4 |
|---|---|---|---|---|
| Stereo 2-Way | L-low | L-hi | R-low | R-hi |
| Mono 2-way | 1-low | 1-hi | 2-low | 2-hi |
| Mono 3-way | low | mid | hi | optional |
| Mono 4-way | sub | low | mid | hi |

Each mode is described as follows:

| Mode | Description |
|---|---|
| mono 3-way | Input 1 drives all four outputs. Input 2 is inoperative. |
| mono 3-way + sub | Input 1 drives all outputs. Band 4 normally supplies an additional highpass output (filter board C, highpass) and can be configured to be an additional lowpass output (filter board C, lowpass). Input 2 may be configured to drive Band 4 (not currently implemented). (jumpers set to BB) |
| mono 3-way + tweeters | As above, except band 4 is configured as an additional highpass output. This can be used to augment the high-frequency output of large-format compression drivers instead of running the system in 4-way mode (jumpers set to AA). |
| mono 3-way | Input 1 drives all outputs. Input 2 is inoperative. |
| stereo 2-way | Input 1 drives Bands 1 and 2, input 2 drives Bands 3 and 4. |
| mono 2-way | Input 1 drives all outputs. This is similar to stereo 2-way mode, except that input 1 drives both crossovers. |

Figure 5-2 shows the relationships between the crossover boards and the inputs and outputs.

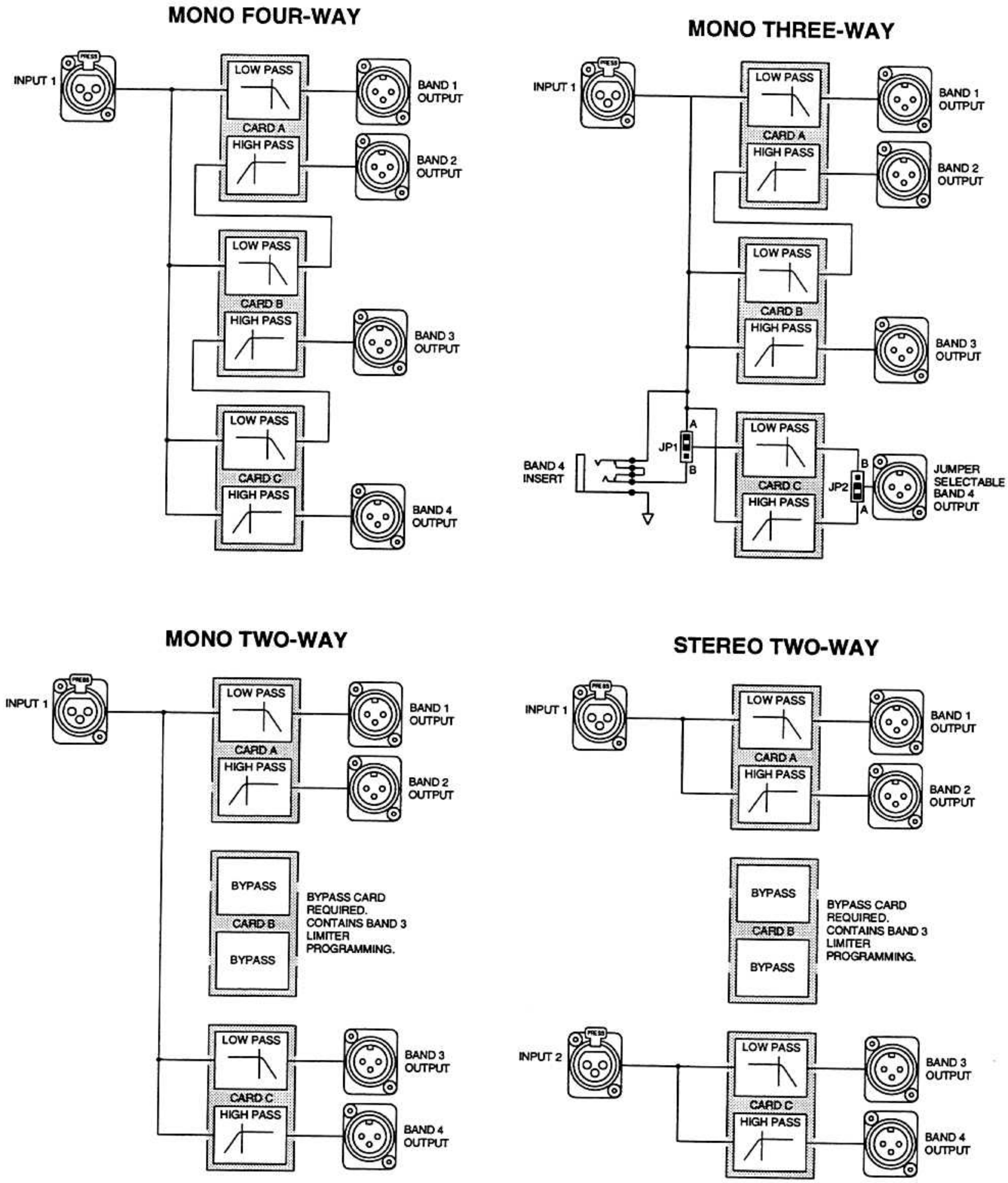



**Figure 5-2. The relationship between the individual crossover filter cards and the inputs and outputs.**

# 6. Fast First Time Setup

Follow these instructions to get your 524 up-and-running as quickly as possible. The intent of this section is fast setup. If you need something clarified, then you'll find the answer elsewhere in this manual.

## 6.1 Connections

Determine the operating mode for your crossover and refer to the table below. The input and output assignments are given by the table. If you don't know the operating mode for your crossover, apply power only to the crossover and note the illumination of the mode LEDs on the right-hand side of the panel.

| Mode | Band 1 | Band 2 | Band 3 | Band 4 |
|---|---|---|---|---|
| Stereo 2-Way | L-low | L-hi | R-low | R-hi |
| Mono 2-way | 1-low | 1-hi | 2-low | 2-hi |
| Mono 3-way | low | mid | hi | optional |
| Mono 4-way | sub | low | mid | hi |

## 6.2 Settings

Set the controls and switches on the front panel as follows:

| | |
|---|---|
| GAIN controls | 8 o'clock (max ccw) |
| MUTE switches | IN |
| THRESHOLD controls | 12 o'clock |
| PHASE switch | OUT |
| PHASE ADJ controls | 0 (full ccw) |

Note: the 524E will NOT pass signal in this condition!

## 6.3 Initial Setup

The 524E's controls and switches are now set according to the preceding section. All connections listed in Section 6.1 and the settings in Section 6.2 are now made. Apply power to the sound system. Connect a music source to a mixer input and set the mixer's controls for a very low level output signal. All gain controls after the mixer should be set to their "normal" positions, or to their unity-gain positions (Use the "normal" positions if you have set the system up before and have already established control settings. Use the unit-gain positions if this is the first time power-up for the system).

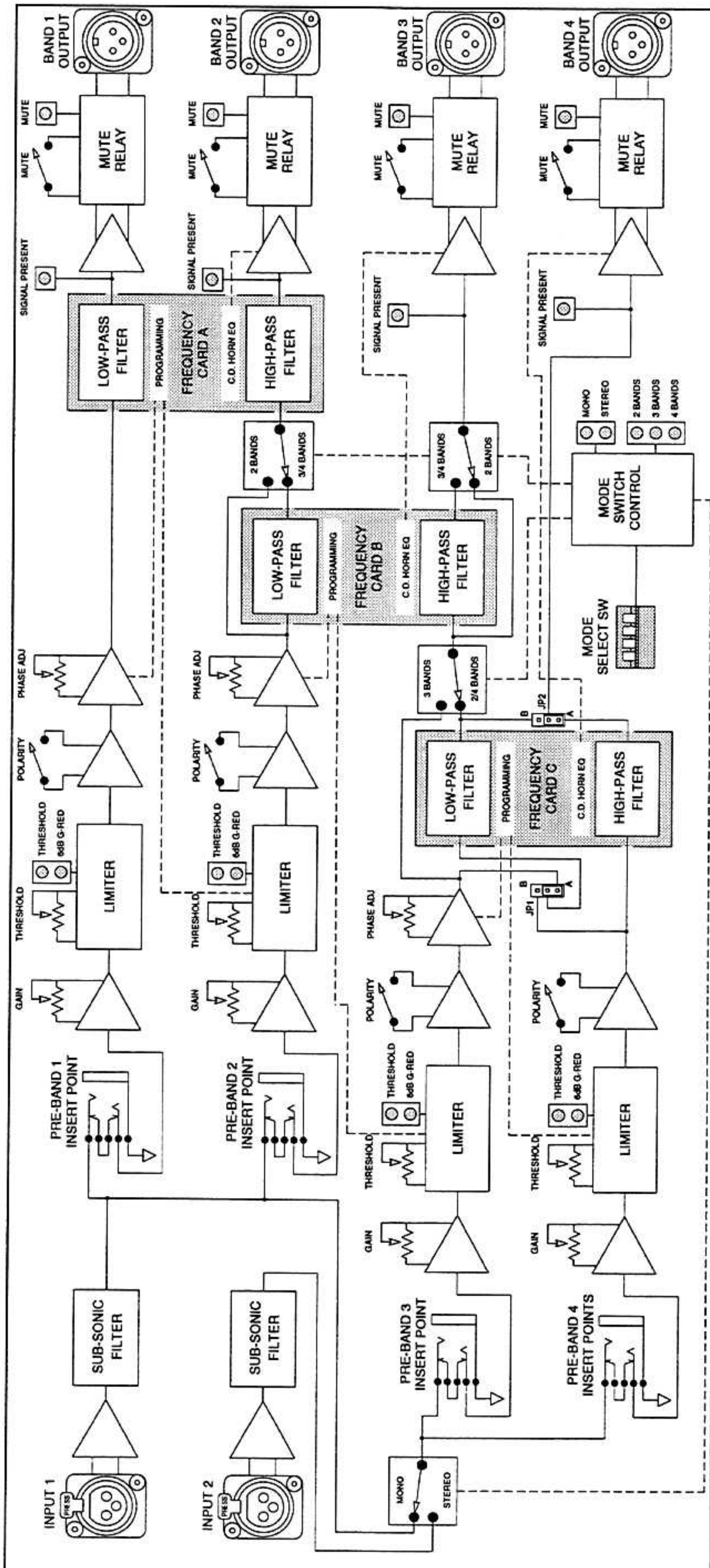
Set all power amplifier level controls to maximum. Starting with the highest-frequency output, un-mute the output by depressing the MUTE switch, then carefully advance the associated GAIN control until you hear sound. Verify that the sound originates from the proper component (highs from tweets, mids from mids, lows from woofs, etc.). If the sound doesn't originate from the proper component, then stop and locate and cure the problem before continuing (the drivers you save are your own!). Tweeters tweeting? Repeat the procedure for the next lowest range, until the entire system has been unmuted.

Next is system balancing. Flatten out any EQ in the signal chain (the console too!). Get out your favorite CDs and start listening. Start out with the low frequency output (the one covering the 100 Hz band) GAIN set at 12 o'clock, then adjust the remaining controls for the higher-frequency ranges for a pleasing, musical balance. Last, adjust any VLF outputs (subwoofers) for the desired amount of sub-low frequency information. Use a variety of material and don't forget trying a single voice on a live microphone.

If you have a Real-Time analyzer (RTA), you can use this to set the system balance prior to using music to double-check your work. If you use the RTA, don't try any equalization right now, just use the RTA to get the different ranges more-or-less balanced for now.

## 6.4 Final Control Settings

At this time, you should have music coming from your system. Note that we haven't touched the PHASE controls or switches, or the limiter controls. These controls require test equipment for setup. The setting procedure can be found in the next section.



INPUT 1
INPUT 2
PRESS
SUB-SONIC FILTER
SUB-SONIC FILTER
MONO
STEREO
PRE-BAND 1 INSERT POINT
PRE-BAND 2 INSERT POINT
PRE-BAND 3 INSERT POINT
PRE-BAND 4 INSERT POINTS
GAIN
THRESHOLD
LIMITER
THRESHOLD
6dB G-RED
POLARITY
PHASE ADJ
LOW-PASS FILTER
PROGRAMMING
FREQUENCY CARD A
C.D. HORN EQ
HIGH-PASS FILTER
FREQUENCY CARD B
FREQUENCY CARD C
2 BANDS
3/4 BANDS
3 BANDS
2/4 BANDS
JP1
JP2
A
B
MODE SWITCH CONTROL
MODE SELECT SW
MONO
STEREO
2 BANDS
3 BANDS
4 BANDS
SIGNAL PRESENT
MUTE
MUTE RELAY
BAND 1 OUTPUT
BAND 2 OUTPUT
BAND 3 OUTPUT
BAND 4 OUTPUT

# 7. Using the 524E

This section is intended for more advanced users. If you are a first-time user of an electronic crossover, we recommend that you start out by using the procedure found in "Fast, First-Time Setup."

## 7.1 Block Diagram

The block diagram for the 524E can be found on the previous page. Please take a moment and take note of the following:

1. The pre-band insert jacks are full-range and precede the crossover filters, limiters, and gain controls for each band.
2. The mode-related switching occurs after the pre-band insert jacks.
3. The limiter time constants for band 1 are located on the main PCB.

## 7.2 installation

The 524E may be installed free-standing or rack mounted. No special ventilation requirements are necessary.

| | |
|---|---|
| Mechanical | One rack space (1.75 inches) required, 10 inches depth (including connector allowance). Rear chassis support recommended for road applications. |
| Electrical | 105-125 VAC, 17 watts. |
| Connectors | XLR-3 female for inputs, XLR-3 male for outputs, TRS female for sidechain. Pin 2 of the XLR connectors is "Hot." |

## 7.3 Setting the Limiters

Each output of the 524 has an adjustable peak limiter. By picking the proper threshold setting, the limiters may be set to do one of the following:

1. Protect the sound system by ensuring that the power amplifiers never clip.
2. Protect the sound system by ensuring that the maximum peak output of the power amplifiers never exceeds some arbitrary level. This arbitrary output level could be based on a maximum desired SPL reading, limitations of the drivers, or experience based on previous abuse.
3. A combination of 1 and 2, above.

Note: To properly set the limiter threshold, you must have a sine wave oscillator, AC voltmeter or oscilloscope, or a sound level meter (SLM). Connect everything as shown below:

1. Determine the maximum output level desired from each frequency band. This may be accomplished by: measuring the clipping level of the amplifier output, converting the maximum input power rating of the loudspeakers into a voltage, converting a maximum SPL level backwards into electrical power input to the loudspeaker(s).
2. Replace the loudspeaker(s) with dummy load resistors.
3. Set the oscillator frequency to be within the frequency band of the output being set.

4. Adjust the oscillator output for the level determined at step one as displayed on the AC voltmeter or oscilloscope.

5. Adjust the limiter threshold control so that the LIMIT THRESHOLD LED just illuminates.

6. Repeat steps 3 through 6 for the remaining bands.

Note: If you are using an SLM to set a maximum acoustical level, then reading the SLM replaces step four in the above procedure. You can use music or pink noise in lieu of sine waves.

Caution: Don't blow up your sound system. Take the time to understand exactly what you are doing when you adjust the limiter thresholds. Understand the setup and the pitfalls. Don't try to make this adjustment with sine waves unless the loudspeakers are disconnected.

Disclaimer: Symetrix Inc. is not liable in any way for any damages that result from, during, or as a result of this procedure.

If you don't have any test equipment, you can make a best-guess at a limiter setting using the following procedure. The resulting setting will keep your power amplifiers out of clipping (which is far better than letting them clip!), but will not necessarily provide the highest degree of protection for your sound system.

1. Disconnect the loudspeakers.

2. Drive the system with music or pink noise until you see the low-frequency amplifier's clipping indicators illuminate on peaks.

3. Adjust the appropriate band's limiter threshold until you just-barely see the limiter threshold LED illuminate.

4. Turn off the low-frequency power amplifier.

5. Continue increasing the signal level fed to the 524 until you see the power amplifier's clipping indicators illuminate for the next frequency band.

6. Adjust the appropriate limiter threshold control until the limiter threshold LED on the 524 illuminates.

7. Turn off the power amplifier.

8. Repeat steps 5 through 8 for the remaining frequency bands.

9. Re-connect the loudspeakers

Finally, here is a procedure that will prevent the sound system from being operated beyond a specific SPL. If you pick an SPL within the capabilities of your system, then this method will protect your system.

1. Using music, with the loudspeakers connected, adjust the mixer controls until the overall level is just slightly past the desired level.

2. Adjust the limiter threshold controls until the limiter threshold LEDs illuminate.

3. If you reach the minimum setting on the threshold control without seeing the threshold LED, then you must decrease the gain of the power amplifier for that band, and increase the corresponding gain control on the 524E to make up the difference.

Disclaimer: Symetrix Inc. is not liable in any way for any damages that result from, during, or as a result of this procedure.

## 7.4 Setting the Phase Controls

There are three phase controls, positioned between each of the four sets of controls on the front panel. These controls vary the phase of the lower band by the amount (0 to 180 degrees) shown on the front panel. Use this control in conjunction with the PHASE REV switch (which provides for a further 180 degrees of phase rotation).

The 524E uses Linkwitz-Riley crossover filters which are characterized by the fact that adjacent bands are in-phase at the crossover frequency. To obtain accurate acoustical energy summation it may be necessary to adjust the phase relationship of adjacent bands to allow for phase errors in the loudspeaker drivers and/or cabinets.

To achieve this in practice, begin by mechanically aligning the acoustical centers of the various components. If absolute alignment is not possible (for instance, a constant directivity horn on top of a direct-radiating LF cabinet), then try to minimize the difference between the acoustical centers. Now adjust the phase controls at the crossover; aligning the highest frequency band, and then moving downward towards the lowest frequency band. There are several methods possible: a spectrum analyzer and pink noise, a TEF analyzer (Techron Div. of Crown International), or an FFT-type analyzer such as MLSSA (DRA Laboratories).

Using a spectrum analyzer and pink noise, adjust the PHASE control for the smoothest transition through the crossover region. The PHASE switches should be in the out position, unless there is a phase reversal in a loudspeaker, cable, or power amplifier.

Using a TEF analyzer, adjust the PHASE control(s) for the best ETC (energy-time curve).

Using MLSSA, adjust the PHASE control for minimum excess phase response. (Refer to Loudspeaker Phase And Acoustic Center in the MLSSA manual).

Finally, in lieu of test equipment, use a sine wave set at the crossover frequency and at a level that doesn't damage the equipment (or your hearing), and adjust the PHASE control for maximum level.

If you don't have any test equipment, then you don't have much choice except to use your ears. We can't give you any recommendations as to what to listen for; just twiddle until it sounds right. Don't be alarmed if the controls don't make a very audible difference.

# 8. Applications

Here are a few special applications that we've come up with here at the factory. If any of you can think of something really novel, let us know and we'll consider sending you a can of slug chowder or some chocolate-covered espresso beans from Starbucks for your trouble.

## 8.1 Optional 3-way Modes

In three-way mode, the jumpers located between crossover cards B and C determine the usage of the Band 4 output. The jumpers are both always set to the same letter (AA or BB, but not AB or BA). We'll leave it up to you to figure out why these configurations aren't useful (we've already done this, so the slug-chowder offer doesn't apply).

With the jumpers set at AA, the Band 4 output is suitable for an additional high-frequency output. You might use this if you use large-format compression drivers for the high-frequency element in your system (like JBL 2441s) and want to use a smaller driver (like JBL 2405s or 2404s) to just add a bit more sizzle, without forcing a rolloff in the 2441's high-end. In this mode, the Band 4 limiter, polarity switch, and level controls are functional. The high-pass section of crossover card C sets the lower frequency limit of this output.

With the jumpers set at BB, the Band 4 output can be used for subwoofers. The low-pass section of crossover card C sets the upper frequency limit of the output. In this mode, the Band 4 limiter, polarity switch, and level controls are functional. You can drive the output separately by using the Band 4 insert jack as an input. Use a tip-ring-sleeve plug with the ring connection left open. There is no easy way to use the second balanced input for this purpose without performing surgery on the circuit board.

## 8.2 Using the Band Insert Jacks

The preceding section describes one use for the band-insert jacks. Another usage is to insert additional time delay into the signal path of each frequency band to compensate for a cluster design that has too much physical separation between components than the phase-shifters in the 524E can compensate for.

You can also use the jacks to insert custom equalization or special filtering for each band of your system. Since the insert jacks are unbalanced I/O points, the filters or equalizers connected to these jacks should be nearby, preferably in the same rack. If you need to balance these points, we recommend trying the inputs (insert-point returns) first, and then the outputs, and then only if needed. Transformers are probably the easiest way to go about this task.

# 9. Troubleshooting Chart

| Symptom | Possible Cause |
|---|---|
| No output | Check cables and connections |
| | Are inputs driven by outputs, and outputs driving inputs? |
| | Verify cables by patching input and output connections together, at the unit.<br>**CAUTION:** Do this only at low signal levels! |
| | Check for AC power presence |
| | Check input by plugging headphones **halfway** (so that you access the ring connection of the TRS jack) into any of the band-insert jacks and listening for input signal |
| | Check output by plugging headphones into output jack |
| | If you are using the band-insert jacks, remove the plug from the insert jack and check for signal at the band-output. |
| | Are the output(s) muted? |
| | Is the crossover mode correct for your application? |
| | Are crossover frequency boards correctly installed (**very important**, and **very easy** to screw up)? |
| No limiter action | Check threshold control setting. |
| | Signal levels may be too low. |
| Limiter LEDs ON continuously | Check crossover boards for proper insertion and seating. |
| Adjacent bands seem to interact | Check crossover boards for proper insertion and seating. |
| Distortion | Check input signal. Is it too hot, or is it already distorted? |
| | Check output loading. Should be above 600 ohms? |
| | Are amplifier(s) clipping? |
| No LED display | Is the unit plugged in, and turned on? |
| No LED display at turn on | Is the AC outlet OK? |
| | Is the fuse OK? |

## 10. 524E Multi-Mode Electronic Crossover Limited Warranty

This Symetrix product is designed and manufactured for use in professional and studio audio systems. Symetrix, Inc. (Symetrix) warrants that this product, manufactured by Symetrix, when properly installed, used, and maintained in accordance with the instructions contained in the product's operator's manual, will perform according to the specifications set forth in the operator's manual.

Symetrix expressly warrants that the product will be free from defects in material and workmanship for one (1) year. Symetrix' obligations under this warranty will be limited to repairing or replacing, at Symetrix' option, the part or parts of the product which prove defective in material or workmanship within one (1) year from date of purchase, provided that the Buyer gives Symetrix prompt notice of any defect or failure and satisfactory proof thereof. Products may be returned by Buyer only after a Return Authorization number (RA) has been obtained from Symetrix and Buyer will prepay all freight charges to return any products to the Symetrix factory. Symetrix reserves the right to inspect any products which may be the subject of any warranty claim before repair or replacement is carried out. Symetrix may, at its option, require proof of the original date of purchase (dated copy of original retail dealer's invoice). Final determination of warranty coverage lies solely with Symetrix. Products repaired under warranty will be returned freight prepaid via United Parcel Service by Symetrix, to any location within the Continental United States. Outside the Continental United States, products will be returned freight collect.

**The foregoing warranties are in lieu of all other warranties, whether oral, written, express, implied or statutory. Symetrix, expressly disclaims any IMPLIED warranties, including fitness for a particular purpose or merchantability. symetrix's warranty obligation and buyer's remedies hereunder are SOLELY and exclusively as stated herein.**

This Symetrix product is designed and manufactured for use in professional and studio audio systems and is not intended for other usage. With respect to products purchased by consumers for personal, family, or household use, Symetrix **expressly disclaims all implied warranties, including but not limited to warranties of merchantability and fitness for a particular purpose.**

This limited warranty, with all terms, conditions and disclaimers set forth herein, shall extend to the original purchaser and anyone who purchases the product within the specified warranty period.

Warranty Registration must be completed and mailed to Symetrix within thirty (30) days of the date of purchase.

Symetrix does not authorize any third party, including any dealer or sales representative, to assume any liability or make any additional warranties or representation regarding this product information on behalf of Symetrix.

This limited warranty gives the buyer certain rights. You may have additional rights provided by applicable law.

## Limitation of Liability

The total liability of Symetrix on any claim, whether in contract, tort (including negligence) or otherwise arising out of, connected with, or resulting from the manufacture, sale, delivery, resale, repair, replacement or use of any product will not exceed the price allocable to the product or any part thereof which gives rise to the claim. In no event will Symetrix be liable for any incidental or consequential damages including but not limited to damage for loss of revenue, cost of capital, claims of customers for service interruptions or failure to supply, and costs and expenses incurred in connection with labor, overhead, transportation, installation or removal of products or substitute facilities or supply houses.

# 11. Repair Information

Should you decide to return your 524E to Symetrix for service, please follow the following instructions.

## 11.1 Return Authorization

Symetrix will service any of its products for a period of five years from the date of manufacture. However, no goods will be accepted without a Return Authorization number.

BEFORE SENDING ANYTHING TO SYMETRIX, CALL US FOR AN RA NUMBER. JUST ASK, WE'LL GLADLY GIVE YOU ONE! CALL (206) 282-2555 WEEKDAYS, 8AM TO 4:30 PM PACIFIC TIME.

## 11.2 In-Warranty Repairs

To get your unit repaired under the terms of the warranty:

1. Call us for an RA number.
2. Pack the unit in its original packaging materials.
3. Include your name, address, etc. and a brief statement of the problem. Your daytime telephone number is very useful if we can't duplicate your problem.
4. Put the RA number on the outside of the box.
5. Ship the unit to Symetrix, freight prepaid.

Just do those five things, and repairs made in-warranty will cost you only the one-way freight fee. We'll pay the return freight.

If you choose to send us your product in some sort of flimsy, non-Symetrix packaging, we'll have to charge you for proper shipping materials. If you don't have the factory packaging materials, then do yourself a favor by using an oversize carton, wrap the unit in a plastic bag, and surround it with bubble-wrap. Pack the box full of Styrofoam peanuts. Use additional bubble-wrap if you must ship more than one unit per carton. Be sure there is enough clearance in the carton to protect the rack ears (you wouldn't believe how many units we see here with bent ears). We won't return the unit in anything but original Symetrix packaging. Of course, if the problem turns out to be operator inflicted, you'll have to pay for both parts and labor. In any event, if there are charges for the repair costs, you will pay for return freight. All charges will be COD unless you have made other arrangements (prepaid, Visa or Mastercard).

## 11.3 Out-of-Warranty Repairs

If the warranty period has passed, you'll be billed for all necessary parts, labor, packaging materials, and any applicable freight charges.

Remember, you must call for an RA number before you send the unit to Symetrix.

## 12. Specifications

| | |
|---|---|
| **Type** | Linkwitz-Riley multi-mode crossover with band-limiters and driver alignment correction. |
| **Inputs** | |
| number | 2, electronically balanced |
| impedance | > 10 kilohms |
| CMRR | > 40dB @ 1kHz |
| connectors | XLR female |
| max level | +18 dBu, balanced or unbalanced |
| **Outputs** | |
| number | 4, electronically balanced (balanced output with grounded center tap.) |
| source impedance | 200 ohms, balanced<br>100 ohms, unbalanced |
| max level | +24 dBm balanced<br>+18 dBm unbalanced |
| connectors | XLR male |
| **Pre-band inserts** | |
| number | 4, one per band |
| minimum load Z | 600 ohms |
| output source Z | 100 ohms, unbalanced |
| return input Z | 10 kilohms, unbalanced |
| max return level | +18 dBu |
| connector | 1/4" TRS, Tip = return, ring = send (Soundcraft convention) |
| **Performance** | |
| THD | .03%, measured at passband center, limiter bypassed, 600 ohm load, +6dBm level. |
| Noise floor | better than -85dB, unweighted |
| S/N Ratio | 109dB, to balanced output |
| **General** | |
| Gain, nominal | 0 dB |
| Gain range | +/- 12 dB via front panel controls |
| Limiter Threshold | Adjustable between -5 dBu and + 20 dBu |
| Inter-band phase | Continuously adjustable between 0 and 180 degrees. Polarity switch provides additional 180 degrees. |
| Subsonic Filter | 20 Hz, nominal, 4-pole modified Butterworth. |
| Crossover Slopes | 24 dB/octave, Linkwitz-Riley alignment. |
| Crossover Frequency | Programmed via plug-in circuit board (3 per unit) |
| Limiter time constants | Programmable via crossover frequency board. |
| Operating Modes | Mono and stereo 2-way, mono 3-way and mono 4-way. |
| **Power Requirements** | 117 VAC, 50-60 Hz, 140 ma, 17 watts |
| 230 VAC, 50-60 Hz, 70 ma, 17 watts | |
| **Physical** | |
| Size | 1.75x 19 x 9.6 (HWD, inches), 1U |
| Weight | 11 lbs / 5 kg |

*Note: in the interest of continuous product improvement, all specifications are subject to change without prior notice.*

## 12.1 Architects and Engineer's Specifications

The crossover shall be a two-input, four-output model capable of providing one channel of two, three, or four way frequency division, or two channels of two way frequency division.

The unit shall have interchangeable filter cards which may be configured to provide second, third, or fourth order filter realizations at any frequency. The filter frequency cards may also be configured to provide high frequency pre-emphasis for systems using constant directivity horns.

Each output channel shall have a peak limiter with adjustable threshold. Front panel LED indicators shall indicate when the output signal is above the limiter threshold and an additional LED shall indicate when 6dB gain reduction has occurred. The limiter's attack and release times shall be set by means of resistors on the user-interchangeable filter cards. Front panel controls shall provide 360 degree control of the phase of each individual output. Each band shall have output mute switches with LED status indicators. The gain of each output channel shall be adjustable over a +/- 12dB range via a front panel control. A fourth-order highpass filter shall be available for LF driver protection with a user specifiable cutoff point. Each output channel shall also have a 1/4" TRS insert jack wired Tip=Return, Ring=Send, Sleeve=Ground

Rack-mounting hardware shall be integral to chassis top, sides and face. Chassis top and sides shall be formed from 12 gauge CRS. All XLR connectors shall be mounted on, and supported by, chassis panels. The crossover shall occupy one rack space. (1U)

The inputs shall be active balanced bridging designs terminated with 3-pin XLR (AES/IEC standard wiring). The input circuitry shall incorporate RFI filters. The outputs shall be active balanced designs having low, equal source impedances and terminated with 3-pin XLR (AES/IEC standard wiring)

The inputs shall accommodate +18 dBu signals (balanced or unbalanced) without distortion, and the outputs shall be capable of delivering +24 dBm balanced or +18 dBm unbalanced into a 600 ohm load.

Total-harmonic-distortion shall not exceed .01% measured at bandpass center, +6dB level, 600 ohm load with limiter bypassed. Signal-to-noise ratio shall be at least 109dB (re clipping) at each balanced output.

There shall be no transients transmitted to the output terminals during either turn-on, turn-off.

The crossover's built-in power supply shall incorporate a torroidal power transformer and operate on 117V nominal AC (105-130V) 50/60 Hz (230V nominal, 207-253V AC, 50 Hz where applicable).

The unit shall be a Symetrix Incorporated Model 524E Multi-Mode Crossover.

# 13. PCB Layouts and Schematics

**Note:** The printed circuit board layouts and schematics in this section are intended for use only by qualified personnel.

**Caution:** *These servicing instructions are for use only by qualified personnel. To avoid electric shock do not perform any servicing other than that contained in the operating instructions portion of this manual unless you are qualified to do so. Refer all servicing to qualified service personnel.*

These schematics and layouts are provided for reference use only, for use by qualified service personnel and for use in answering certain technical questions that are beyond the scope and intent of this manual. The schematics and layouts in this manual were accurate at the time that this manual was written. Your actual product may contain changes not shown on these drawings. The inclusion of this material in this manual in no way obligates Symetrix to provide updated information or to inform users of any changes, past or pending.

A complete service manual is available from the factory for a nominal charge. Please contact the Symetrix Service Department at the address listed in Section 11 of this manual.

## 13.1 Troubleshooting Hints

If you are attempting repair of your 524E, the following tips and hints may be useful, especially if you are not familiar with operational amplifiers.

The first thing that you should check are the power supplies. Their nominal voltage should be within 5% of the noted value on the schematic. The IC regulators used are current limited and short-circuit protected; their output voltage drops under excessive load (like something downstream that draws excessive current).

In audio amplifiers that utilize operational amplifiers as their active gain element, the two feedback resistors establish the working gain of the circuit. In Symetrix equipment, and other equipment using bipolar (separate plus and minus) power supplies, the nominal DC output voltage of each stage should be at or very near zero volts.

If an opamp's output is at or near one of the power supply rails, this usually means that the opamp has failed. The exception to this rule is when the circuit configuration uses the opamp as a DC amplifier or as a comparator.

When used as a DC amplifier, the output should follow the input signal (modified by the circuit's gain equation).

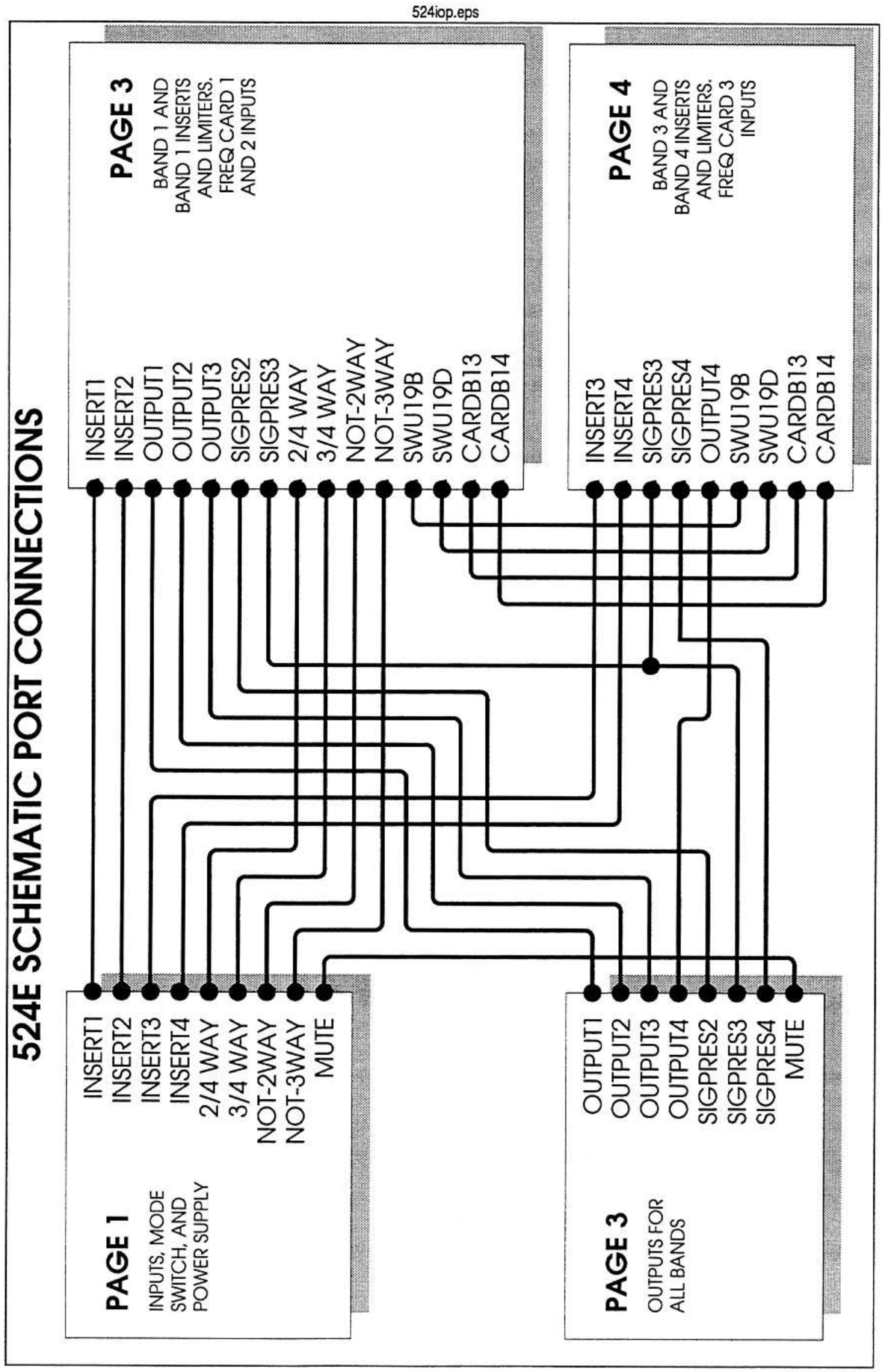
When used as a comparator, the opamp's output swings between the two supply rails and there should be no intermediate output state.

Units using substantial amounts of digital circuitry are probably best serviced at the factory.

## 13.2 Additional Reading

You can find additional information on the design and applications of operational amplifiers in the following text:

"Audio IC Op-Amp Applications," Walter G. Jung, Copyright 1987, *Howard W. Sams & Company*, Indianapolis, IN.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524E SCHEMATIC PORT CONNECTIONS
PAGE 3
BAND 1 AND BAND 1 INSERTS AND LIMITERS. FREQ CARD 1 AND 2 INPUTS
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INSERT2
OUTPUT1
OUTPUT2
OUTPUT3
SIGPRES2
SIGPRES3
2/4 WAY
3/4 WAY
NOT-2WAY
NOT-3WAY
SWU19B
SWU19D
CARDB13
CARDB14
PAGE 4
BAND 3 AND BAND 4 INSERTS AND LIMITERS. FREQ CARD 3 INPUTS
INSERT3
INSERT4
SIGPRES3
SIGPRES4
OUTPUT4
SWU19B
SWU19D
CARDB13
CARDB14
PAGE 1
INPUTS, MODE SWITCH, AND POWER SUPPLY
INSERT1
INSERT2
INSERT3
INSERT4
2/4 WAY
3/4 WAY
NOT-2WAY
NOT-3WAY
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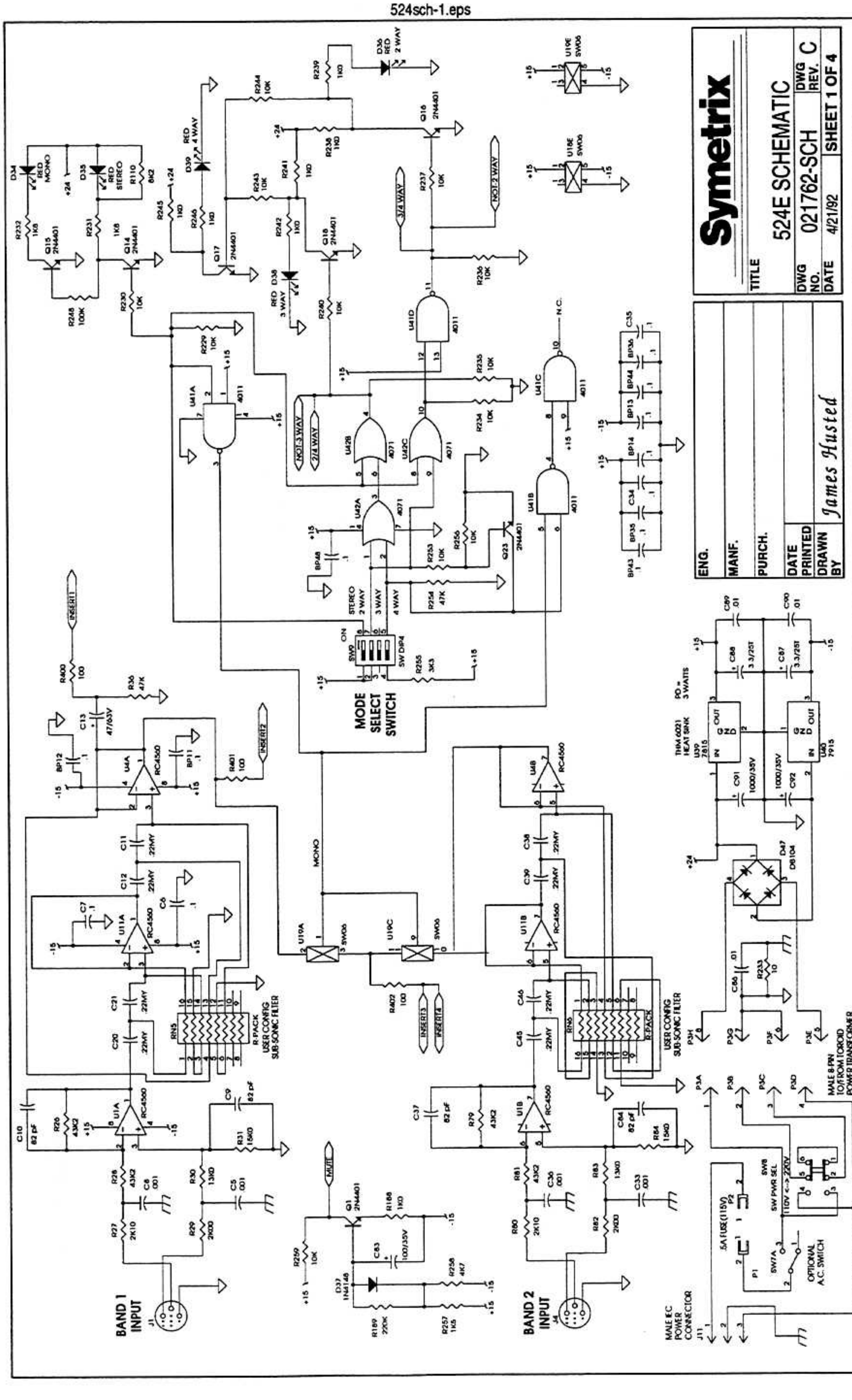
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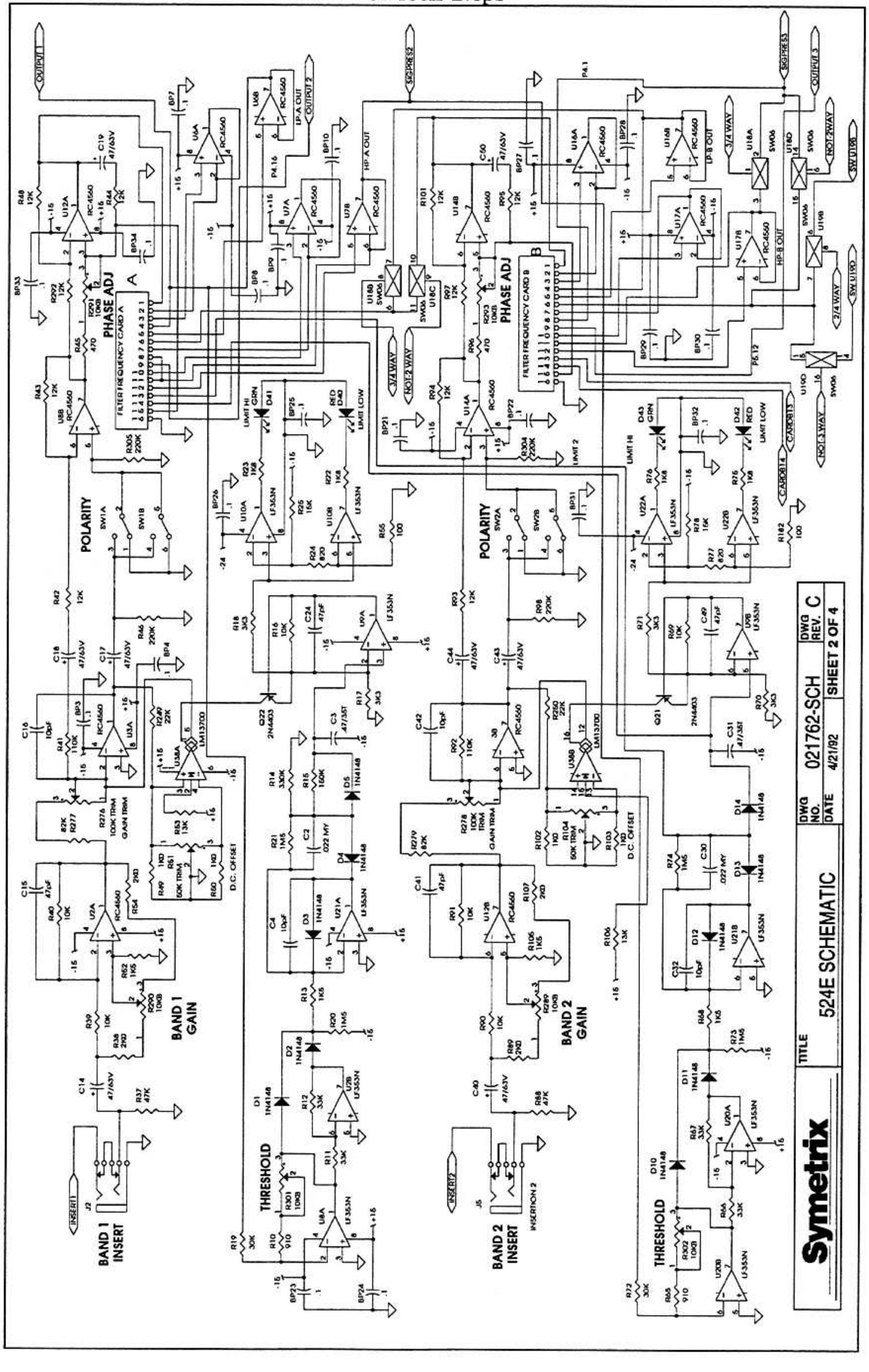
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D.C. OFFSET

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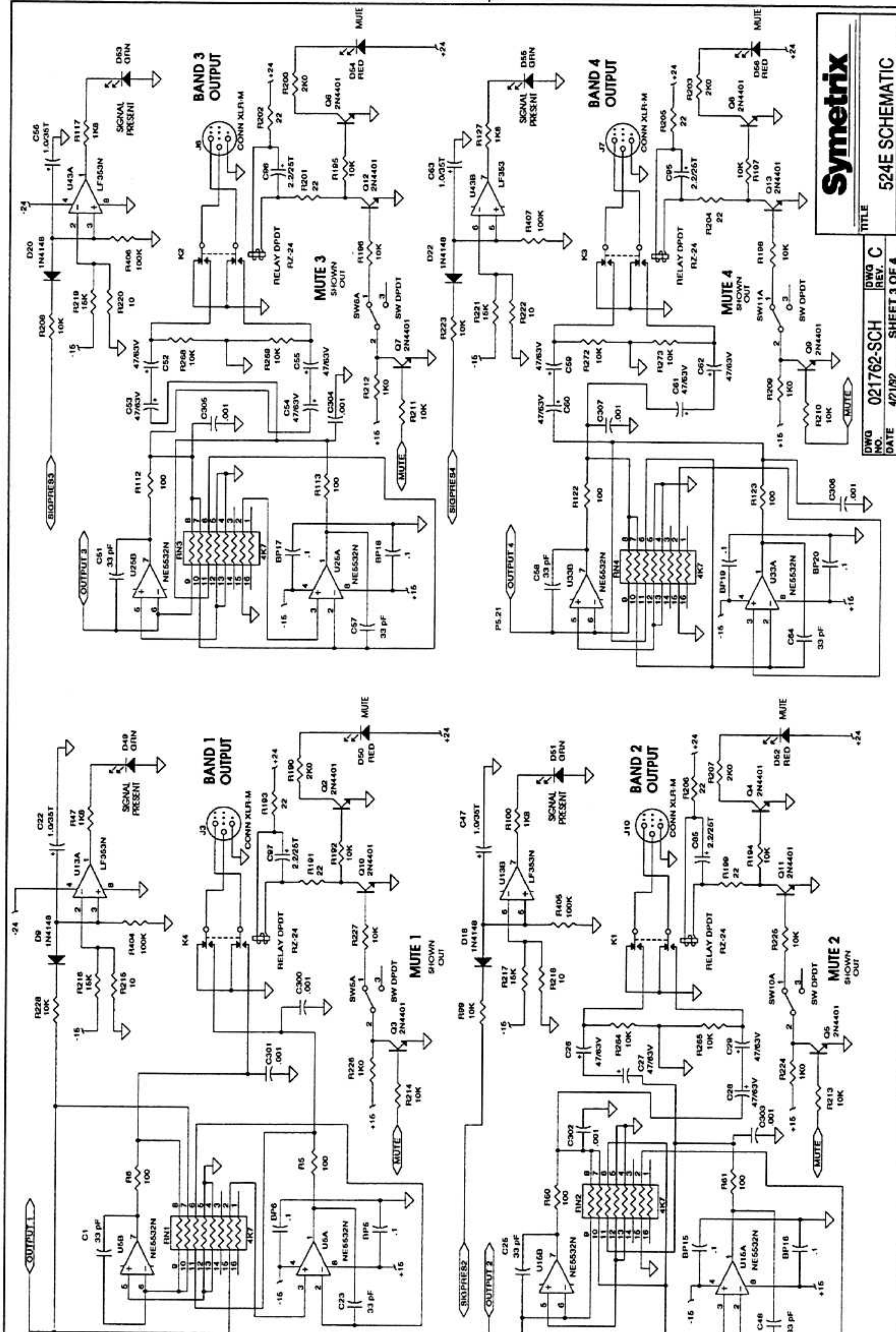
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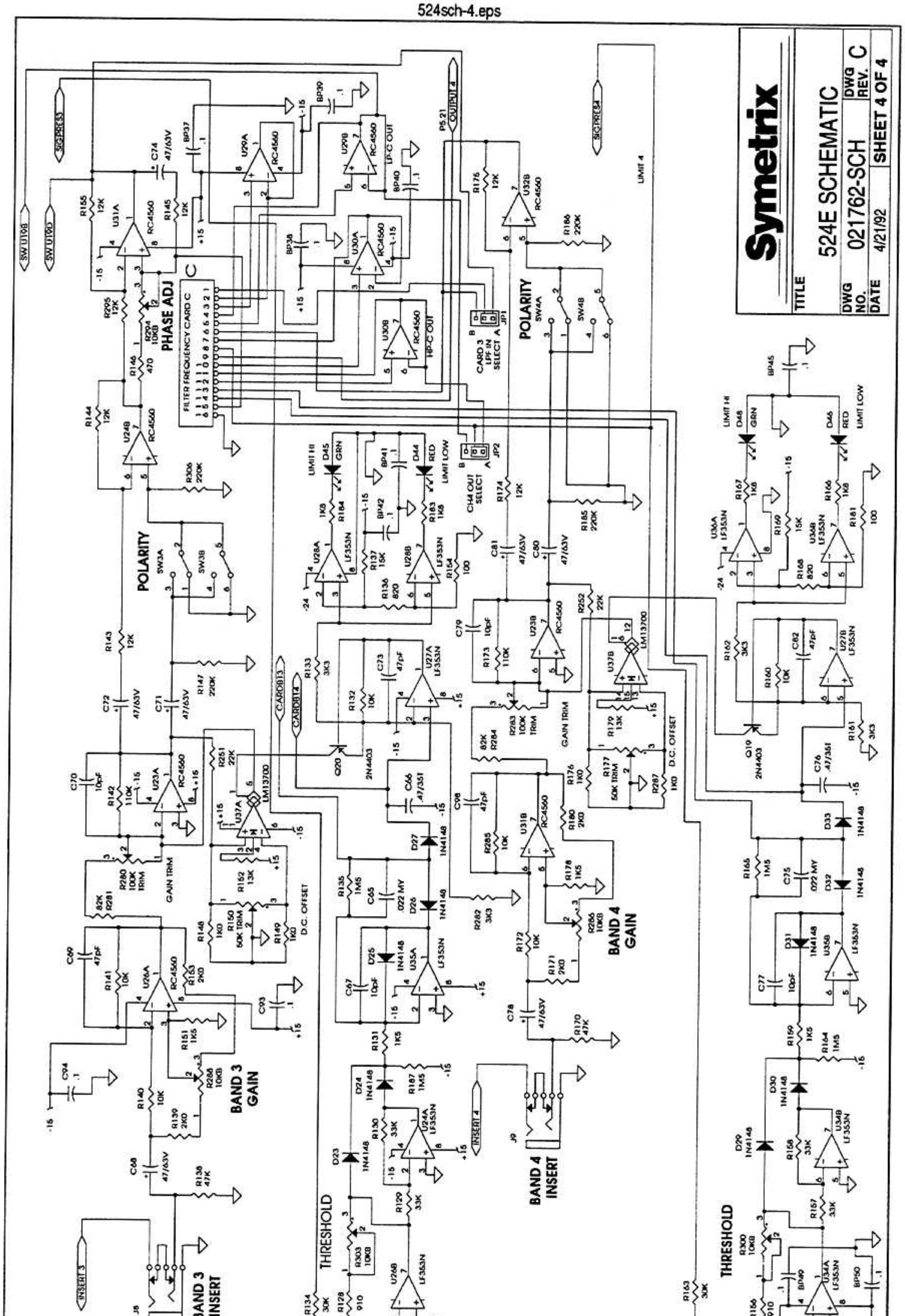
BAND 2 OUTPUT
BAND 3 OUTPUT
BAND 4 OUTPUT
MUTE 1 SHOWN OUT
MUTE 2 SHOWN OUT
MUTE 3 SHOWN OUT
MUTE 4 SHOWN OUT
SIGNAL PRESENT
RELAY DPDT RZ-24
CONN XLR-M
SW DPDT

524sch-4.eps


Symetrix
TITLE
524E SCHEMATIC
DWG NO.
021762-SCH
DWG REV.
C
DATE
4/21/92
SHEET 4 OF 4

# Appendix C. Disassembly Instructions

## Crossover frequency board access

To access the crossover frequency boards:

1. Disconnect the AC power supply from the 524E.
2. Locate the access port cover, located at the center-rear of the unit.
3. Remove the two screws that fasten the cover to the rear of the unit.
4. Remove the circuit boards within by pulling straight back, towards the rear of the unit.
5. When replacing boards, turn the board so that the component side of the board faces the output connectors, locate the female connector on the motherboard (a flashlight helps!), and push the board until the connectors mate and seat.
6. Ensure that every pin of the board has mated (be sure that you don't have the board plugged in one pin off). If you manage to plug the board in incorrectly, the limiter LEDs for that channel will probably illuminate and/or the limiter controls or polarity switches may/will cause strange things to happen to adjacent channels. If this occurs, get out the flashlight and inspect the boards. Try removing and replacing the board. Don't feel badly if you have to try several times.
7. Changing crossover boards is at least an order of magnitude more difficult if the 524E is mounted in a rack.
8. Replace the access cover. Do not push on the screws when reinstalling them; doing so may dislodge the PEM-nuts that are pressed into the chassis.

## Chassis Disassembly

To access the interior of the unit:

1. Disconnect the AC power cord and all audio connections from the unit. Remove the unit from the rack.
2. Remove three screws from each end of the unit, and 2 counter-sunk screws from the top of the unit. The top cover now lifts off.

## Circuit Board Removal

To remove the circuit board:

1. Perform the Chassis Disassembly procedure, above.
2. Remove the four phillips head screws located at each corner of the front panel.
3. Unlock the XLR connectors by inserting a 2mm slot-head screwdriver into the hole located between pins 1 and 2 of the XLR connector insert. Twist the retaining lug CCW to unlock the connector body. Repeat for all six connectors.
4. Remove the two screws securing the IEC power connector, remove the nuts securing the LED circuit board to the standoffs, and remove the six screws securing the PCB to the chassis. If you're nimble and/or clever you can do this without removing the LED circuit board.
5. Remove the circuit board by sliding it out of the front of the chassis. You may have to push on the XLR connector bodies to loosen them up (you can also use a big stick, but you may hurt them in the process).
6. When reassembling, remember to lock the XLR connector bodies into the connector shells.

# Appendix D. Bibliography

The following papers and articles may be of interest:

**Active Crossover Networks for Noncoincident Drivers**, Siegfried H. Linkwitz, *Journal of the Audio Engineering Society*, Jan/Feb 1976.

**A Three-Enclosure Loudspeaker System with active delay and crossover**, Siegfried Linkwitz, *Wireless World*, 1978 (multi-part article), reprinted in *Speaker Builder*, 2-4/1980.

**Constant-Voltage Crossover Network Design**, Richard H. Small, *Journal of the Audio Engineering Society*, January 1971.

**Dividing Networks for Loud Speaker Systems**, John K. Hilliard, H. R. Kimball, *Journal of the Audio Engineering Society*, November, 1978. Reprinted from *Academy Research Council Technical Bulletin*, 1936 Volume, March 3, 1936.

**Operational Amplifier of Ideal Electronic Crossover Networks**, J. R. Ashley, L. M. Henne, *Journal of the Audio Engineering Society*, January, 1971.

**The Constant Directivity White Horn White Paper**, PA Bible addition 6, *Electro-Voice Inc, Buchanan MI, 49107.*

**Note 107: Linkwitz-Riley Crossovers**, Dennis Bohn, *Rane Corporation, Mukilteo WA 98275.*

Technical Notes Volume 1, Number 5: **Field Network Modifications for Flat Power Response Applications**, *JBL, Northridge CA, 91329*

Technical Notes Volume 1, Number 8: **Characteristics of High-Frequency Compression Drivers**, *JBL, Northridge CA, 91329*

Technical Notes Volume 1, Number 11: **Controlled Power Response: Its Importance in Sound Reinforcement System Design,** *JBL, Northridge CA, 91329*

## Appendix A. Crossover Frequency Card Stuff

The 524E's crossover frequencies (and other parameters) are programmed via plug-in circuit boards. Programming consists of soldering the proper components onto the board. Each board programs the following parameters:

1. High-pass crossover filter frequency
2. Low-pass crossover filter frequency
3. Low-pass delay
4. Limiter attack time constant
5. Limiter release time constant
6. CD horn EQ.

### Stock Frequencies

The following crossover frequencies are available from the factory: 70, 80, 100, 125, 150, 160, 200, 250, 315, 400, 500, 630, 800, 1000, 1250, 1500, 1600, 2000, 2500, 3150, 4k, 5k, 6k, 7k 7k5, 8k, 9k, 10k. For the most part, these are ISO preferred one-third octave center frequencies.

### Custom Frequencies

You may elect to construct your own crossover programming boards. The raw circuit boards are available from Symetrix as an accessory. Three boards are required for each 524E.

The circuit boards have additional pads present for resistors that can be used to make special values by paralleling two resistors of different values. The schematic for the crossover board shows where these additional resistors are located in the circuit. If you use 1% resistors, these are not needed, but if 1% resistors are hard to find, you may find it easier to create that special value by paralleling two 5% values.

The circuit board is laid out for 5mm lead spacing box capacitors. Suitable units are made by Southern, WIMA, and Siemens. Use 5% tolerance parts (or 10% parts measured and matched on a capacitor bridge). If you use 10% parts, match them and record their absolute value. Then use this value to compute the resistor values.

A computer program (IBM-PC) is available from Symetrix to aid in performing these calculations. The formulas used are presented in the remainder of this appendix. A module order form may be found at the end of this appendix.

### Linkwitz-Riley High-pass crossover:

Choose C7, $f_c$, then,

$$R15 = R11 = \frac{0.2251}{C7\,fc}$$

$$R13 = R14 = R15,\ R9 = R10 = R11$$

$$C7 = C8 = C9 = C10$$

Where:
R is the resistor value in ohms
C is the capacitor value in farads
$f_c$ is the crossover frequency in Hertz

## Linkwitz-Riley Low-Pass Crossover:

There are two ways to compute the values for the low-pass crossover. The first method (the easy one) is to set R1, R2, R3, R4, R5, R6, R7, and R8 equal to R11. Then C1, C2, C3, C4, C5, and C6 are equal to C7. Note the abundance of identical values. This method uses the paralleled resistor pads to create values that are 1/2 of those used in the high-pass crossover.

Method two uses the following equations (**Note:** R2, R4, R6, and R8 are **NOT** used):

Choose: C1, fc

$$R_1, R_5 = \frac{1}{8.886 f c C_1}$$

$$R_3 = R_7 = R_1 = R_5$$

$$C_1 = C_2 = C_3 = C_4 = C_5 = C_6$$

Where:
R is the resistor value in ohms
C is the capacitor value in farads
$f_c$ is the crossover frequency in Hertz

## Limiter Time Constants

The limiter time constants are individually adjustable via R17 and R18. R17 controls the attack time and R18 controls the release time. These components are located on the crossover frequency boards. The time constant components for limiter 1 are located on the main PCB and are factory preset for low-frequency operation (band 1 is always the woofers). For limiter 1, R15 controls the attack time, R14 controls the release time. The factory values are suitable for low-frequency operation (R14 = 330k, R15 = 150k). For stereo two-way operation, you may want crossover board B to match these values (since board B controls the band 3 limiter).

### Limiter Attack Time

r = t (seconds) / 0.47e-6

### Limiter Release Time

r = t (seconds) / 0.47e-6

## CD Horn EQ

Assume R20 = 4k7, f = 3300 Hz (mass rolloff of most drivers)

The 3 dB frequency is approximately $\frac{1}{6.28 R_{20} C_{12}}$

Maximum lift approximately $20\log\left(\frac{(4700 / R_{19}) R_{20}}{(4700 / R_{19}) + R_{20}}\right)$

We suggest: R19 = 2k2, R20 = 4k7, C12 = 8n2.

The values given result in about 10 dB of boost @ 20k, starting at about 3500 Hz.

## Delay Programming

The frequency where the phase shift will be 90 degrees, with the control set at 12 o'clock, is:

$$f \cong \frac{15974}{C}$$

Where: C is the capacitor value expressed in nF

The control has a fair amount of range; as a starting point, use your crossover frequency. Look at the table presented at the end of this section for the values used at the factory (we rely on the wide range of the control so that we can use fewer different capacitor values).

## Subsonic Filter

The subsonic filter (input high-pass filter) is located on the main PCB. The filter is a 4-pole approximate Butterworth filter made by cascading two 2-pole filters. This filter may be altered to other alignments (although we'll leave this to you), or retuned to a different frequency.

The subsonic filters are tuned via two resistor networks located near the input connectors at the left-center edge of the circuit board. Refer to Figure A-6. The resistor networks are marked RN5 and RN6. Adjacent to them are two single-row socket strips marked SK5 and SK6. In the usual configuration, all resistors are equal-value. This will change if your configuration requires LF boost for sixth-order Thiele alignments.

You have three options for the tuning resistors:

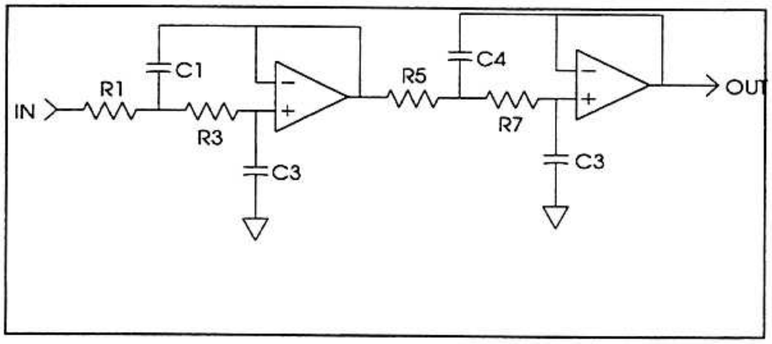
1. Use a resistor network (8 independent resistors) inserted into RN5 and RN6. Although resistor networks are only available in values corresponding to the 10% resistor values, their absolute tolerance is quite good, and the match between resistors on the same network is outstanding (usually better than 1%).
2. Use 1% resistors soldered to an 16-pin dip header which is then inserted into RN5 and RN6.
3. Use 1% MIL style RN55C resistors with their leads formed to 0.5" spacing, inserted between the single-row socket (SK5/SK6) and the DIP socket (RN5/RN6). There should be an empty socket hole under each resistor. Be sure to bottom the resistor leads in the sockets.

The formula for the resistor value is:

$$R = \frac{63778}{f}$$

## LF boost for 6th-order alignments

Sixth-order Thiele-Small alignments require an auxiliary filter. Typically this takes the form of an underdamped 2nd-order highpass filter. In the 524E, you can realize the boost using one-half of the input highpass filter, and realize some further out of band attenuation using the remaining half of the input filter. Please contact the factory for assistance.




Choose $R_1$, then:

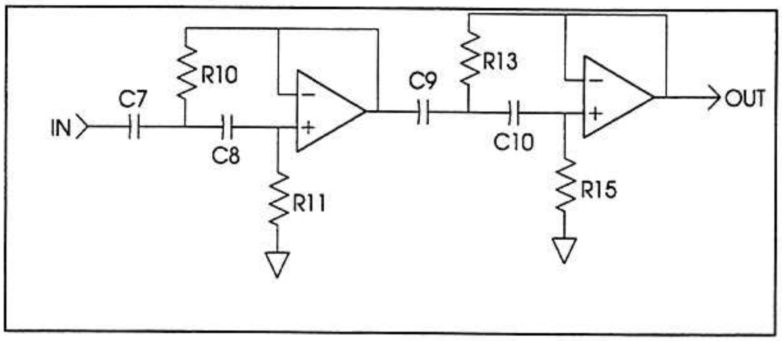
$$C = \frac{1}{6.28Rf}$$

$R_3 = R_1, R_1 = R_5, R_5 = R_7$

$C_1 = k_1C, C_3 = k_2C$

$C_4 = k_3C, C_6 = k_4C$

**Figure A-1. 24 dB/Octave Butterworth lowpass filter.**




Choose C, then:

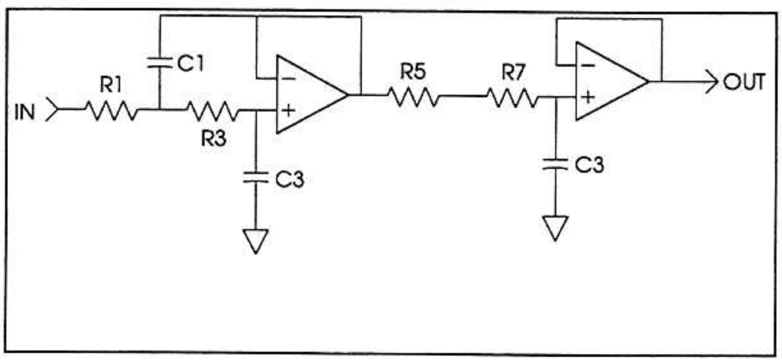
$C = C7, C7 = C8, C = C9, C9 = C10$

$$R = \frac{1}{6.28Cf}$$

$R_9 = k_1R, R_{11} = k_2R$

$R_{13} = k_3R, R_{15} = k_4R$

**Figure A-2. 24 dB/Octave Butterworth highpass filter.**




Choose C, then:

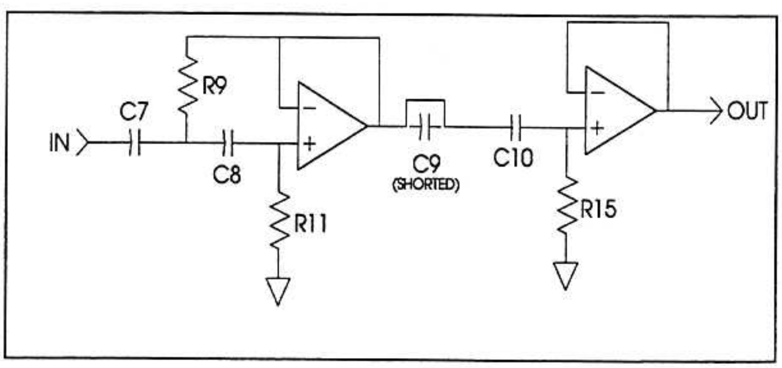
$$R = \frac{1}{6.28fC}$$

$R_1 = R, R_1 = R_3, R_5 = R$

$R_7 = 0\Omega$

$C_1 = k_3C, C_3 = k_4C$

**Figure A-3. 18 dB/Octave Butterworth lowpass filter.**




Use R and C from Fig. A - 3, then:

$C_7 = C, C_7 = C_8, C_{10} = C$

$C_9$ = short circuit.

$R_9 = k_3R$

$R_{11} = k_4R$

**Figure A-4. 18 dB/Octave Butterworth highpass filter.**

## Non-Linkwitz-Riley Configurations

| Slope | $k_1$ | $k_2$ | $k_3$ | $k_4$ |
|---|---|---|---|---|
| 24LP | 2.614 | 0.383 | 1.082 | 0.921 |
| 24HP | 0.383 | 2.614 | 0.921 | 1.082 |
| 18LP | 1 | n/a | 0.5 | 2.0 |
| 18HP | 1 | n/a | 2.0 | 0.5 |

The formulas presented earlier in this section are for crossovers using the Linkwitz-Riley alignment (-6dB at crossover point, 4th order). If your configuration uses underlap, overlap, or some other filter characteristic then these formulas are invalid.

Figures A-1, A-2, A-3, and A-4 show the virtual schematic of each crossover filter. The reference designators used (R and C numbers) match those used on the Crossover PCBs. The table lists the *k* factors used to calculate values for 18 dB/octave and 24 dB/octave Butterworth filters. Use the *k* factors and the following formulas to obtain the value of the appropriate filter component. Please contact the factory for assistance if these concepts aren't clear to you.

### 24 dB/Octave Butterworth

For the lowpass filter (Figure A-1):

1. Select a value for R1 between 2k and 50k.
2. R3 = R1, R5 = R7
3. Calculate $C = \frac{1}{2\pi r f}$
4. Calculate $C_1 = k_1 C$
5. Calculate $C_3 = k_2 C$
6. Calculate $C_4 = k_3 C$
7. Calculate $C_6 = k_4 C$

For the highpass filter (Figure A-2):

1. Select a value for C between 1nF and 100nF.
2. C = C7, C7 = C8, C = C9, C9 = C10
3. Calculate $R = \frac{1}{2\pi C_7 f}$
4. Calculate $R_9 = k_1 R$
5. Calculate $R_{11} = k_2 R$
6. Calculate $R_{13} = k_3 R$
7. Calculate $R_{15} = k_4 R$

### 18 dB/Octave Butterworth

For the lowpass filter (Figure A-3):

1. Select a value for C. between 1nF and 100nf
2. Calculate $R = \frac{1}{2\pi fC}$
3. R1 = R, R1 = R3, R5 = R. R7 = 0 ohms (short circuit)
4. Calculate $C_1 = k_3 C$
5. Calculate $C_3 = k_4 C$

For the highpass filter (Figure A-4):

1. Use the values for R and C calculated for the 18dB/Octave lowpass filter.
2. C7 = C, C7 = C8, C10 = C. C9 = short circuit.
3. Calculate $R_9 = k_3 R$
4. Calculate $R_{11} = k_4 R$

## Crossover PCB Details

The 524E crossover programming boards have some unique features built-in to facilitate construction. All resistors in the frequency-determining networks have an extra set of layout pads connected in parallel with them to facilitate creating unusual values (in lieu of 1% resistors). Likewise, two of the capacitors in the lowpass portion of the crossover have paralleled pads. The schematic of the crossover programming PCB should make this clear. A component location drawing for a crossover board as well as a bypass board may be found in Figure A-5. Figure A-6 is a worksheet that you can use to help remember what goes where.

At the factory, we use the paralleled pads to create components whose composite values are in a 2:1 or 1:2 relationship to each other. The active filter configuration used dictates the relationship of the values; thus creating a resistor value that is half of another or a capacitor value that is twice that of another is a simple matter of paralleling two like-valued parts. This is preferable to two additional parts of differing value.

The following tables illustrate the assignments used on the crossover cards for each operating mode.

## Mode: 2-way mono or stereo

| | OUTPUT JACK | XOVER FREQ CARD | LIMITER PARAM. LOC. | CD EQ LOC | PHASE CAP (C11) | PHASE FREQ |
|---|---|---|---|---|---|---|
| Low 1 | Band 1 | A | Main PCB | none | A | match A crossover |
| High 1 | Band 2 | A | A | A | n/a | n/a |
| Low 2 | Band 3 | C | B | n/a | C | match C crossover |
| High 2 | Band 4 | C | C | C | none | n/a |

**Note:** The Band 3 limiter programming is located on board B. For most applications, its programming should match that of Band 1 which is permanently programmed for low frequency operation.

Board B should be configured for bypass operation.

## Mode: 3-way mono

| | OUTPUT JACK | XOVER FREQ. CARD | LIMITER PARAM. LOC. | CD EQ LOC | PHASE CAP (C11) | PHASE FREQ |
|---|---|---|---|---|---|---|
| Low | Band 1 | A | Main PCB | none | A | match A crossover |
| Mid | Band 2 | lo-mid A mid-hi B | A | A | B | match B crossover |
| Hi | Band 3 | B | B | B | C | omit C11 (board C) |
| Optional | Band 4 | C | C | C | none | |

**Note:** If your particular configuration calls for CD horn EQ **and** the mid-hi crossover frequency lies within the range of the CD horn equalizer **and** both the mid and high ranges are covered by CD horns, you must add CD EQ components for both card A and card B. Use the same CD EQ component values for both cards (R19, R20, C12). If only the mid band is covered by a CD horn (for instance, the high band uses a JBL 2405), then only the mid band (card B) requires CD EQ.

If band 4 is not used, then card C should be configured for bypass operation with C11 omitted.

## Mode: 4-way mono

| | OUTPUT JACK | XOVER FREQ. CARD | LIMITER PARAM. LOC. | CD EQ LOC | PHASE CAP (C11) | PHASE FREQ |
|---|---|---|---|---|---|---|
| Sub | Band 1 | A | Main PCB | none | A | match A crossover |
| Low | Band 2 | sub-low A<br>lo-mid B | A | A | B | match B crossover |
| Mid | Band 3 | lo-mid B<br>hi-mid C | B | B | C | match C crossover |
| Hi | Band 4 | C | C | C | none | n/a |

**Note**: If your particular configuration calls for CD horn EQ **and** the mid-hi crossover frequency lies within the range of the CD horn equalizer **and** both the mid and high ranges are covered by CD horns, you must add CD EQ components for both card B and card C. Use the same CD EQ component values for both cards (R19, R20, C12). If only the mid band is covered by a CD horn (for instance, the high band uses a JBL 2405), then only the mid-high band (card B) requires CD EQ.

## Factory Values

The following tables list the component values used at the factory for various highpass filter and crossover frequencies.

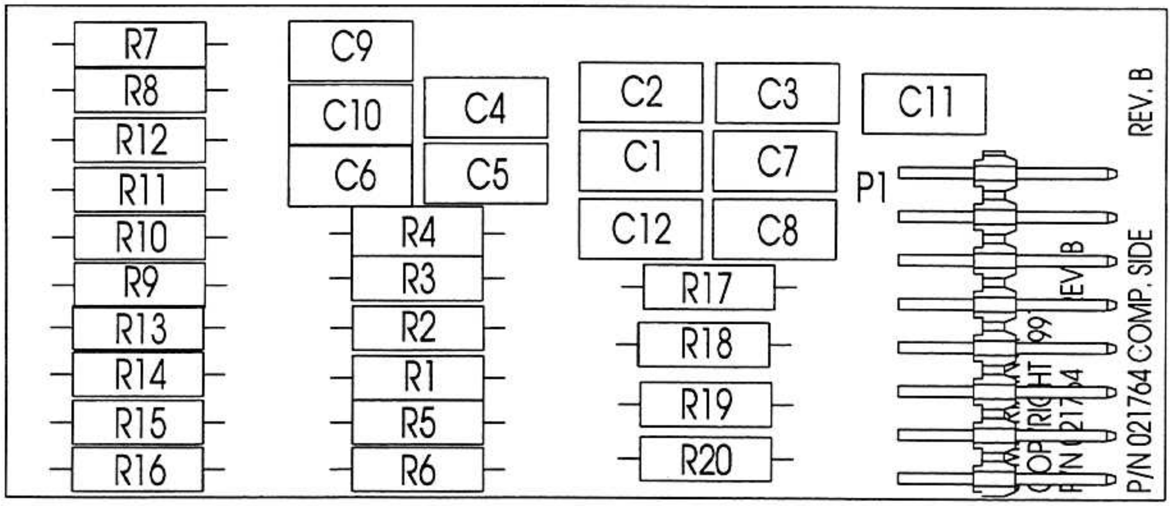
### LF highpass filter:

| F | Actual | Value |
|---|---|---|
| (Hz) | (Hz) | (ohms) |
| 5 | 5.31 | 120K0 |
| 20 | 19.33 | 33K0 |
| 25 | 23.62 | 27K0 |
| 30 | 28.99 | 22K0 |
| 35 | 35.43 | 18K0 |
| 40 | 42.52 | 15K0 |
| 50 | 53.15 | 12K0 |
| 70 | 63.78 | 10K0 |

## Crossover Filter Values:

| F (Hz) | Crossovers R1, R2, R3, R4, R5, R6, R7, R8, R9, R10, R11, R13, R14, R15 | C1, C2, C3, C4, C5, C6, C7, C8, C9, C 10 | Error | Phase (NF) C11 | Limiter Attack R17 | Release R18 | CD-EQ R20 |
|---|---|---|---|---|---|---|---|
| 70 | 68K1 | 47n0 | 0.6% | 150n0 | 120K0 | 240K0 | 4K7 |
| 80 | 60K4 | 47n0 | -0.6% | 150n0 | 110K0 | 220K0 | 4K7 |
| 90 | 53K6 | 47n0 | -0.4% | 100n0 | 110K0 | 200K0 | 4K7 |
| 100 | 47K5 | 47n0 | 1.0% | 100n0 | 110K0 | 200K0 | 4K7 |
| 125 | 38K3 | 47n0 | 0.3% | 68n0 | 100K0 | 180K0 | 4K7 |
| 150 | 31K6 | 47n0 | 1.0% | 68n0 | 100K0 | 150K0 | 4K7 |
| 160 | 30K1 | 47n0 | -0.2% | 68n0 | 100K0 | 150K0 | 4K7 |
| 200 | 23K7 | 47n0 | -1.1% | 47n0 | 91K0 | 130K0 | 4K7 |
| 250 | 19K1 | 47n0 | 0.5% | 47n0 | 91K0 | 110K0 | 4K7 |
| 315 | 71K5 | 10n0 | 0.1% | 33n0 | 82K0 | 100K0 | 4K7 |
| 400 | 56K2 | 10n0 | 0.5% | 22n0 | 82K0 | 82K0 | 4K7 |
| 500 | 45K3 | 10n0 | -0.4% | 22n0 | 82K0 | 68K0 | 4K7 |
| 630 | 35K7 | 10n0 | 0.4% | 15n0 | 75K0 | 62K0 | 4K7 |
| 800 | 28K0 | 10n0 | 0.5% | 15n0 | 75K0 | 51K0 | 4K7 |
| 1000 | 22K6 | 10n0 | -0.4% | 10n0 | 68K0 | 43K0 | 4K7 |
| 1250 | 38K3 | 4n7 | 0.3% | 6n8 | 68K0 | 39K0 | 4K7 |
| 1500 | 15K0 | 10n0 | 0.0% | 6n8 | 68K0 | 33K0 | 4K7 |
| 1600 | 30K1 | 4n7 | -0.2% | 6n8 | 68K0 | 30K0 | 4K7 |
| 2000 | 11K3 | 10n0 | 0.1% | 4n7 | 33K0 | 20K0 | 4K7 |
| 2500 | 19K1 | 4n7 | 0.5% | 4n7 | 33K0 | 20K0 | 4K7 |
| 3150 | 15K4 | 4n7 | -1.0% | 3n3 | 33K0 | 20K0 | 4K7 |
| 4000 | 12K1 | 4n7 | -0.9% | 2n2 | 33K0 | 20K0 | 4K7 |
| 5000 | 9K53 | 4n7 | 0.8% | 2n2 | 33K0 | 20K0 | 4K7 |
| 6000 | 37K4 | 1n0 | 0.3% | 1n5 | 33K0 | 20K0 | 4K7 |
| 7000 | 32K4 | 1n0 | -0.8% | 1n5 | 33K0 | 20K0 | 4K7 |
| 7500 | 6K34 | 4n7 | 1.0% | 1n5 | 33K0 | 20K0 | 4K7 |
| 8000 | 28K0 | 1n0 | 0.5% | 1n5 | 33K0 | 20K0 | 4K7 |
| 9000 | 5K36 | 4n7 | -0.4% | 1n0 | 33K0 | 20K0 | 4K7 |
| 10000 | 4K75 | 4n7 | 1.0% | 1n0 | 33K0 | 20K0 | 4K7 |

Note: R12 and R16 are NOT used.



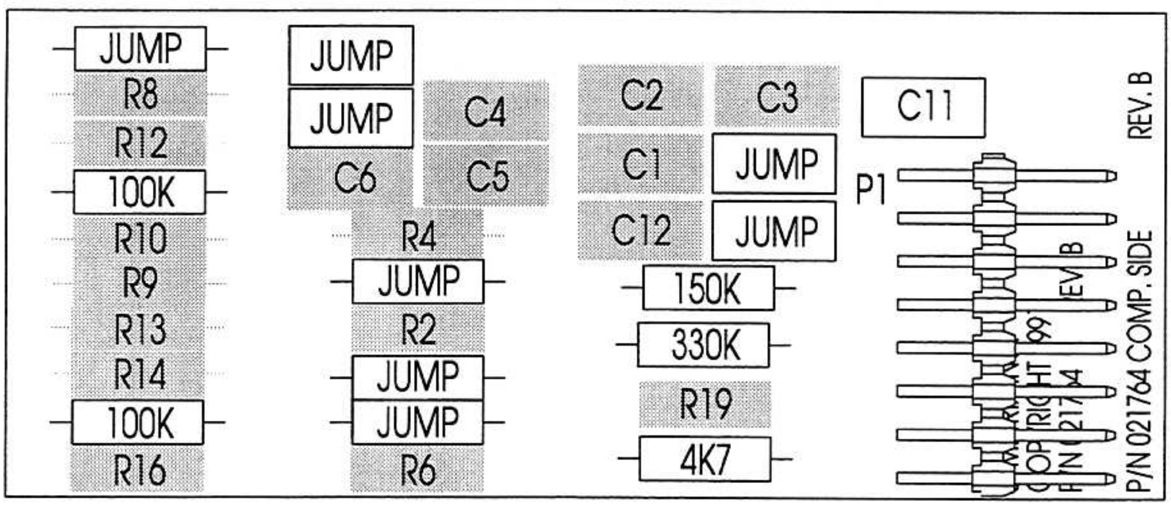




**Figure A-5. The 524E crossover frequency card. The bottom drawing shows the card stuffed as a bypass card (see Appendix B).**

524frm.eps

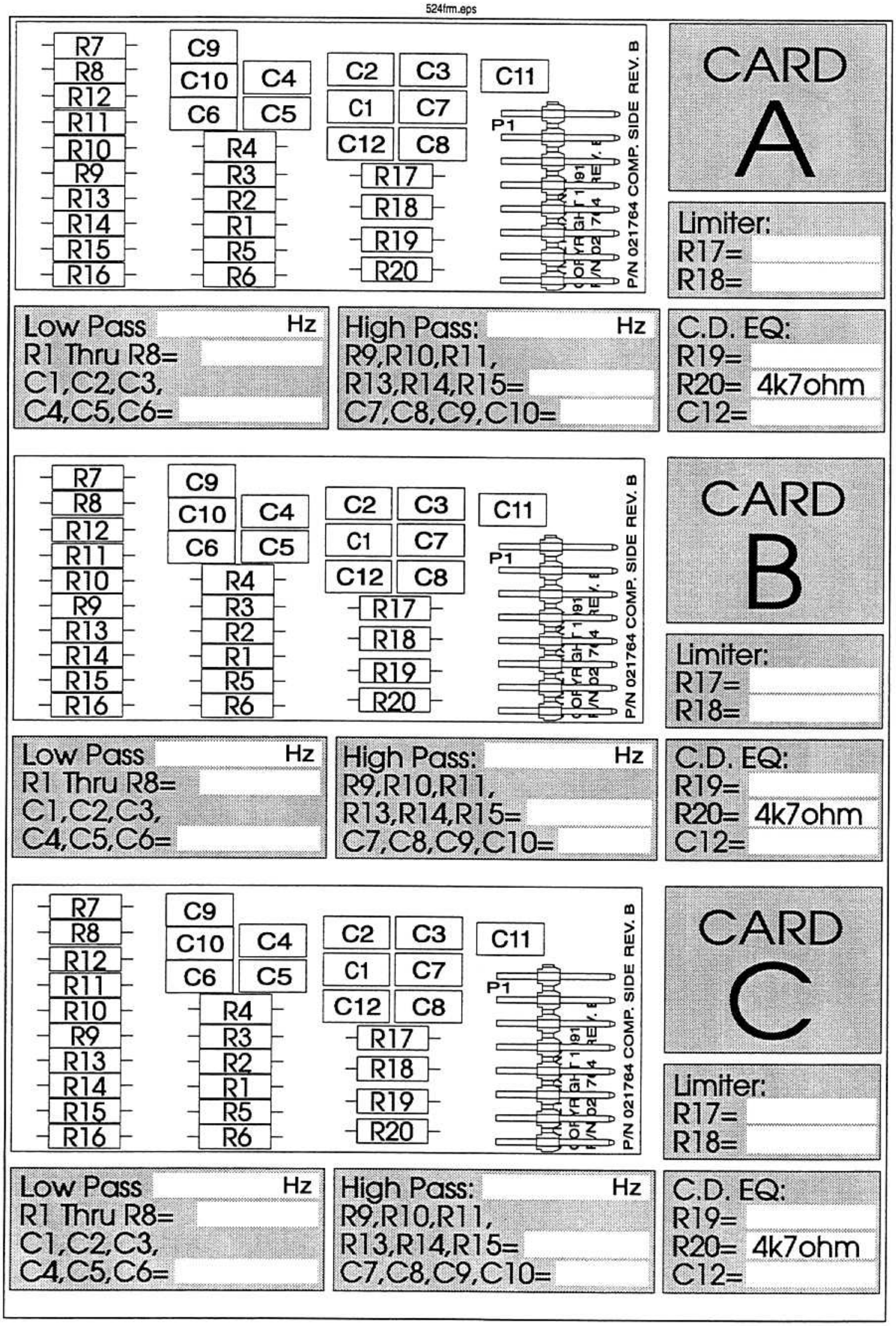



Figure A-6. Worksheet for 524E crossover programming PCB. Use the formulas shown for "Method One"

524lpf.eps

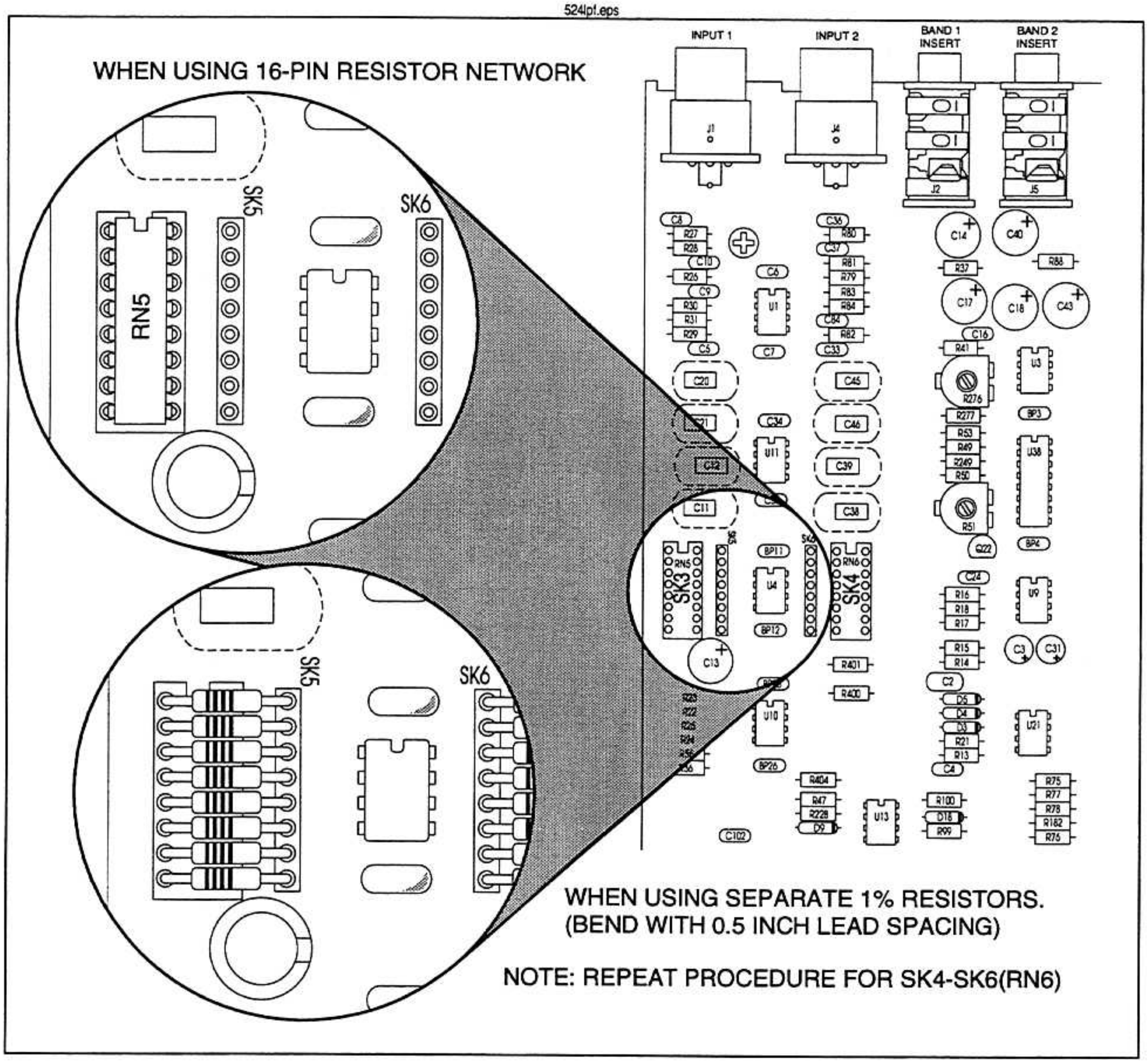



**Figure A-7. Resistor network locations for low-frequency subsonic filter.**

# **Symetrix** 524E Module Information

1 Name ______________________ Date ____________

Company ______________________ PO# ____________

Address ______________________ SO# ____________

City, State Zip ______________________

Phone ______________ Fax ______________

Tech Person ______________ Phone ______________

Instructions:

1. There are 5 sections to this form. Sections 3 and 4 have factory values that will be supplied if you do not specify them here. Please fill out all sections.
2. Please read the other side of this form.
3. Please give us the name of a person (yourself or your customer) who can answer any technical questions that we may have about your crossover's configuration.

2 Crossover Mode and Frequencies **Fill out 1 configuration only.**

Bands are numbered from the lowest frequencies to the highest frequencies. These band numbers also correspond to the like-named outputs on the rear of the 524E. Stock frequencies are listed on the reverse side of this form. If you're ordering for a three- or four-way system and your configuration uses super-tweeters, don't sweat the frequency designations for the bands (i.e. Sub-Low, Low-Mid, etc.), just give us the right frequencies.

☐ Mono 4-way

Sub-Low ________ Hz Low-Mid ________ Hz Mid-Hi ________ Hz

☐ Mono 3-way

Low-Mid ________ Hz Mid-High ________ Hz

☐ Stereo 2-way, Dual-Mono 2-way

Channel 1 ________ Hz Channel 2 ________ Hz

3 Low Frequency Rolloff Note: Factory default is 35 Hz!

☐ 5 Hz ☐ 25 Hz ☐ 30 Hz ☐ 35 Hz

☐ 40 Hz ☐ 50 Hz ☐ 70 Hz

4 CD Horn EQ **Note: Factory default is NONE**

☐ No ☐ Yes ☐ Other ______________________ What?

5 Special Instructions ______________________

______________________

______________________



Fine Print Dept: If you can read this fine print, you don't need to get your eyes checked!

Available crossover frequencies: 70, 80, 100, 125, 150, 160, 200, 250, 315, 400, 500, 630, 800, 1k, 1k25, 1k5, 1k6, 2k, 2k5, 3k15, 4k, 5k, 6k, 7k, 7k5, 8k, 9k 10k

Low Frequency Cutoff: 5, 20, 25, 30, 35, 40, 45, 50, 70 (factory default: 35Hz)

Peaked responses for Thiele-Small sixth-order tunings are available. There are many restrictions. Contact the factory for additional information.

Other frequencies are available from the factory on a special order basis at additional charge.

## Crossover Frequency Selection Notes

The crossover frequencies used in any modern sound system are a matter of system design. The frequencies chosen should take into account the following parameters:

**Cone Driver Limitations** At some upper frequency, the frequency response of most woofers becomes non linear due to the mass controlled rolloff of the woofer cone as well as other factors.

**Compression Driver Limits** Aside from voice coil failure, most high-frequency drivers fail mechanically because some diaphragm constructions are more forgiving of abuse than others (titanium vs beryllium vs aluminum). All compression drivers should be power derated when operated below 1kHz (2kHz for 1-inch throats). This helps account for the increased diaphragm motion that occurs at lower crossover frequencies.

**Polar Pattern** Some designers pick the point at which the two transducer's polar patterns match (taking into account individual driver limitations, of course).

**Power Handling** Compression drivers will withstand higher drive levels when crossed over at higher frequencies because of reduced diaphragm motion requirements. The thermal limit of the voice coil is still the deciding factor, however.

**Driver Response Linearity** It is best to pick crossover frequencies that are within the linear operating region of the particular driver.

**Program Material** The spectral balance of the program material may influence your choice of crossover frequency because of spectral buildups (energy distribution peaks) in the crossover region. It is probably a good idea to shift the crossover frequency slightly to avoid the peak.

# Appendix B. Bypass card programming

Some applications (mono/stereo two-way, sometimes 3-way) require a bypass card for one of the crossover board slots (actually you can insert a card for any frequency into the slot and the 524E will be happy). For two-way stereo or mono, the limiter time constants used should match those used for band 1 (whose components are located on the main PCB). The bypass card is constructed as follows:

| Component | Value | Notes |
|---|---|---|
| R1, R3 | jumper | |
| C1, C3 | omit | |
| R5, R7 | jumper | |
| C7, C8, C9, C10 | jumper | |
| R9, R13 | omit | |
| R11, R15 | 100k | |
| R20 | 4k7 | |
| R17 | 150k | (program same as band 1 for 2-way) |
| R18 | 330k | (program same as band 1 for 2-way) |
| C11 | | program for band 2 (jumper for 2-way) |

Note: all resistors may be 5% units.

For three-way mono applications, board C programs the filters used for the band-4 output. If your application doesn't use band-4, then board C is a don't care situation, as long as there is some sort of board plugged into the socket (we suggest a bypass board.) If your application does use band-4 for another output (ususally for subs), then program board C for the crossover frequency chosen for band-4.