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INSTALLATION AND OPERATION MANUAL

EC650 & TCX650 ELECTRONIC CROSSOVERS



SMART THEATRE SYSTEMS

3856 Green Industrial Way, Atlanta, GA 30341 (404) 452-1820



EC650 AND TCX650 ELECTRONIC DIVIDING NETWORK

CRASH COURSE



For those installers who have installed the TCX650 before, here is a brief checklist of each step of the hookup and calibration adjustments. A detailed description is offered within this manual. If you have not installed this product before, we suggest you become familiar with the unit by reading the manual before attempting installation.

- Install into rack in a well ventilated place. Hook outputs of the LEFT, CENTER, and RIGHT Equalizer to the respective inputs of the TCX650 using two conductor shielded audio cable. Ground the shield at the *receiving end* only.

- Connect a shielded audio cable from the (L)EFT HI output to the input of the LEFT HF amplifier. Connect another shielded cable from the (L)EFT LO output of the TCX650 to the LEFT LF amplifier input.

- Repeat this procedure for the CENTER and RIGHT HF and LF amplifier input.

- Adjust crossover levels using pots behind the security cover for the smoothest transition on RTA screen.

- Turn on TONE oscillator and adjust time delay for the highest peak on RTA screen with DELAY control.

- Connect sub-woofer amplifier using shielded audio cable. See the sub-bass section of this manual for hookup variations.

- Adjust gain of sub-woofer system.

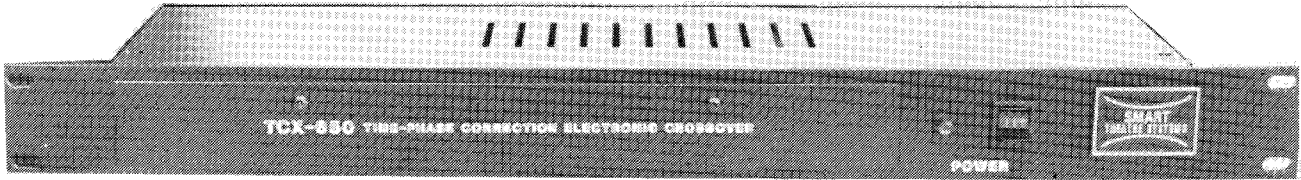
A more complete description of the operation and adjustments of the TCX650 is included in this manual.



CAUTION
RISK OF ELECTRIC SHOCK
DO NOT OPEN



TCX650 ELECTRONIC CROSSOVER



Time-Phase Correction Electronic Dividing Network

The TCX650 Electronic Crossover is designed specifically for Bi-Amplified Theatre Stereo Systems. This unique product contains all the circuitry for three full channels of electronic crossover for the stage speaker systems in the highest quality theatre systems, along with Time-Phase correction for *any 2-way stage speaker system in the industry*. Unlike other products that are intended for only one model of speaker, the TCX650 is fully adjustable over a wide range.

The three separate 12 dB per octave 500 Hz crossovers help avoid the overload distortion by-products present in standard passive crossover networks, for much cleaner sound reproduction at high soundtrack levels. Also bi-amplification, along with Time-Phase correction, produces a "transparency of sound" not found in conventional systems. Leading theatres have discovered this technique and are installing bi-amplified systems as a possible hedge against new soundtrack formats in the future that may demand lower distortion speaker systems.

The SMART TCX650 includes muting relays to reduce system turn-on "thumps" that may occur in high power theatre sound systems. The product is compatible with all stereo sound processors and power amplifiers on the market.

Three Channel Crossover

Output Muting

Time-Phase Correction

500 Hz Crossovers

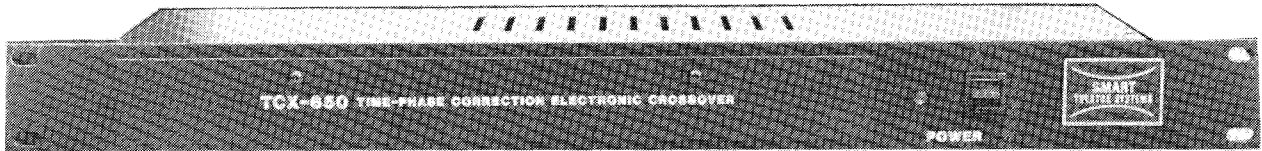
Sub-Bass filtered Output

Easy Adjustment

SMART
THEATRE SYSTEMS

P.O. BOX 80361 ● ATLANTA, GA 30341 ● ☎(404)-452-1820

EC650 ELECTRONIC CROSSOVER & TCX650 TIME-PHASE CORRECTED ELECTRONIC CROSSOVER



TCX650 WITH FRONT SECURITY COVER IN PLACE

The SMART EC650 and TCX650 are sister products that are used for electronically dividing the audio frequency spectrum in bi-amplified theatre stage speaker systems. Both products have the following features:

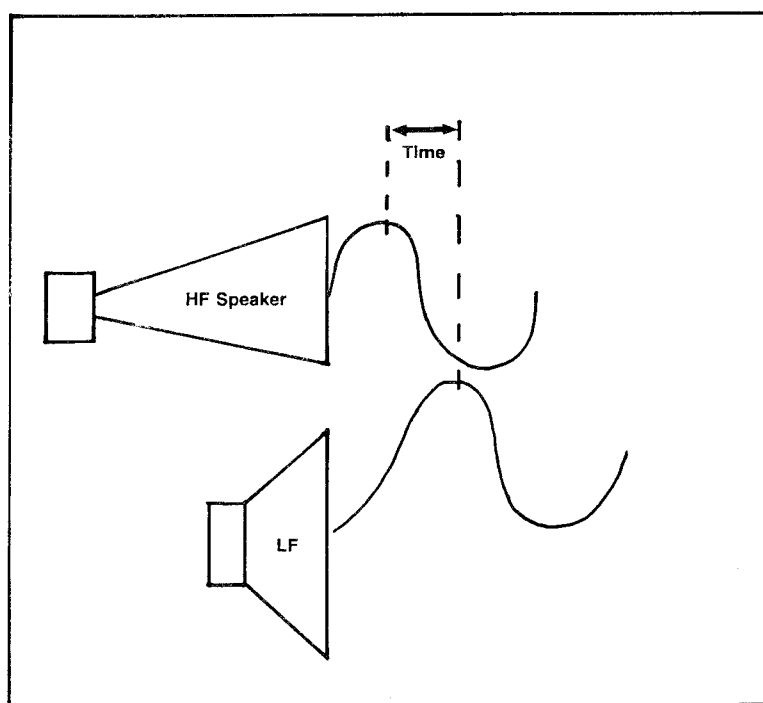
- Three (3) channels of frequency dividing (Crossover).
- 500 Hz ($\pm 10\%$) crossover frequency with 12 dB per Octave slopes.
- Optional factory built 800 Hz crossover points.
- Salen-Key filters for smooth response and stability at crossover.
- Sub-woofer output with a 12 dB per Octave 25 Hz high-pass filter, and 18 dB per Octave 80 Hz low-pass filter.
- Individual output trim controls for each high frequency output and each low frequency output.
- Hidden front panel adjustments behind a removable security cover.
- Delay Output Muting Relays for all channels to stop turn-on pops when the sound system is turned on each day.
- Automatic summing of the LEFT and RIGHT stereo channels for the sub-woofer output. Separate Sub-bass gain control.
- Slim profile 1 3/4 inch panel in a steel chassis.

TCX650 EXTRA FEATURES

The TCX650 has all the additional circuitry for Time-Phase correction of the three stage speaker low frequency woofer sections. All three channels are adjusted with a single control. The perfect tracking of the three channels avoids the bothersome and time consuming process of adjusting each channel separately. If one channel is right, they are all right when using identical speaker systems for the three stage channels. The TCX650 can Time-Phase correct ALL 2-way speaker systems on the market.

A built-in 500 Hz tone generator lets you align the CENTER stage speaker system without having to connect outside signal sources. The tone is turned on by a hidden switch behind the front panel security cover.

WHAT IS TIME-PHASE CORRECTION? Adjacent drivers in a 2-way stage speaker system should be both mechanically and electrically in phase with each other throughout their shared frequency range. Typically, this range of frequencies covers the level range throughout which the two drivers (Bass and HF) are within 6 dB to 10 dB of each other. Normally, 2-pole or 4-pole filters are used in electronic crossovers to achieve a 12 dB per Octave crossover and 24 dB per Octave crossover respectively. In most stage speaker systems the voice coil/diaphragm of the



**TIME VARIANCE BETWEEN THE ARRIVAL OF ONE SOUND
VS THE OTHER AT THE LISTENING POSITION.**

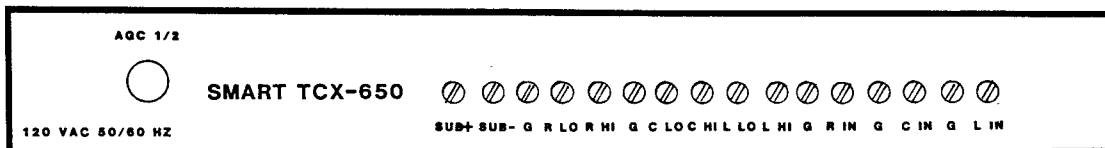
TCX650 Crossover

HF driver is positioned behind the voice coil/cone of the woofer in the bass enclosure and introduces an improper phase relationship between the two transducers when both are reproducing the same frequency at the crossover point. Because both transducers are reproducing the same information at the crossover point, and are not mechanically or electrically aligned, the sound from each will arrive at the listener at slightly different times. Even though this time difference may only be a fraction of a second, the effect is a muddy or poorly defined tone. Also, the sounds from the two speakers will either add or subtract from each other at crossover, above the crossover point, and below the crossover point differently. Time-Phase correction assures a perfect match at all points on or around the crossover frequency point and adds a noticeable clarity to the reproduced sound.

Time-Phase correction electronic dividing networks are offered by several manufacturers in the commercial sound market. Most of these products use *all pass filters* to achieve a small amount of delay to the bass speaker. This scheme has several benefits and some drawbacks. All-pass filters are very quiet circuits. However, a great deal of elaborate switching is required to insert additional poles into the circuit for a wide range of time settings. This makes the devices difficult to set up. Also the commercial units are almost always single or dual channel products. Three channels are required for theatre operation. The SMART TCX650 employs three active variable time delay circuits that may be set to any 2-way speaker system without compromise. Other systems may fall *between* ideal matching because the switches jump in even increments. The TCX650 has been optimized for motion picture playback applications.

HOOKUP INSTRUCTIONS

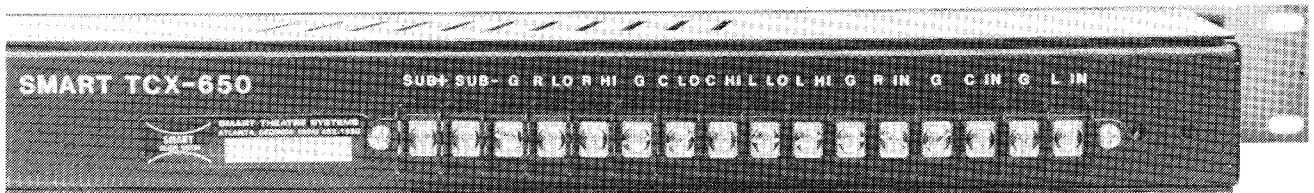
All input and output connections to the TCX650 or EC650 are made through the barrier strip on the rear of the steel chassis. A fanning strip or individual spade lugs on each conductor is recommended for a good clean installation.



INPUTS. The barrier terminals on the right are labeled (L)EFT IN, (C)ENTER IN and (R)IGHT IN. Next to each input is a (G)round terminal. The shield of each audio cable feeding the TCX650 must be connected to the (G) terminal and NOT grounded at the sending end of the cable. The second conductor of the twisted pair audio cable (Low signal path) must *ALSO* be connected to the (G)round terminal of each input channel.

OUTPUTS. Each channel has two outputs. One is the HF (High Frequency) signal which contains all program material above 500 Hz, and the other output is the LF (Low Frequency) material below 500 Hz. They are labeled L HI and L LO, for the LEFT CHANNEL outputs, C HI and C LO for the CENTER CHANNEL outputs, and R HI and R LO for the RIGHT CHANNEL outputs. Connect separate shielded audio cable to each output and route to their respective power amplifier inputs. Ground the SHIELD of these cables at the AMPLIFIER inputs and *NOT* at the TCX650 output terminals.

SUB-BASS OUTPUTS. The TCX650 and EC650 electronic dividing networks have dedicated outputs to drive a separate power amplifier for sub-woofer systems. The band-pass filtering is in the active crossover, and no additional conditioning is required. That means that any standard power amplifier may be used as a sub-woofer amplifier without additional equipment. The output terminals are labeled **SUB +** and **SUB-** with a nearby (G)round terminal. The **SUB +** terminal sends a bass only signal to a single channel amplifier that is in-phase with the Left, Center, and Right stage system outputs. The **SUB-** has the same signal but of opposite phase (inverted polarity). This inverted signal may be handy if the sub-woofer speaker is not aligned mechanically with the stage speakers. Some speaker manufacturers recommend that their sub-woofer cabinet be placed on the floor against the rear wall in order to acoustically load more efficiently. This may place the sub-woofer well behind the stage speakers. The inverted output may be a better choice than the in-phase signal. *DO NOT* connect to both sub-bass output terminals when driving a single channel amplifier.



Another popular scheme in driving sub-woofer systems is to use a dual channel amplifier in what is referred to as a **MONO-BRIDGE** configuration. This results in a three times increase in power output over the amplifier rating into a single channel. A bass signal is fed to one channel of the amplifier from the **SUB +** output terminal, and the other channel is fed with the **SUB-** output. This places the amplifiers in a push-pull arrangement with opposite polarities on the amplifier speaker terminals. The sub-woofer speaker **MUST BE** wired to the "Hot" terminals of the speaker terminals and **NEVER** grounded. One wire of the sub-woofer goes to the HOT output terminal of one channel, and the other wire connects to the HOT terminal of the second amplifier channel.

PLACEMENT OF THE TCX650 IN THE SYSTEM CHAIN. The electronic dividing network must be wired into the system immediately before each power amplifier input. The product is normally fed from a house equalizer. The audio spectrum is then divided with frequencies below 500 Hz sent to the LF amplifier and speaker, and the HF sounds directed to the HF amplifier and speaker. Care should be taken to see that large amounts of bass boost in the house equalizers do not overload the TCX650 because of overdrive in the LF sections of the device.



CALIBRATION

HF AND LF OUTPUT SETTINGS. Each of the three stage channels has an HF (High Frequency) and LF (Low Frequency) OUTPUT control to balance each channel of the bi-amplified speaker system. This feature is particularly handy when driving power amplifiers that do not have individual input gain controls. The OUTPUT controls let you adjust the volume level to each amplifier precisely. This also limits the amount of sound level that the operator can send to the auditorium. You may wish to open all power amplifier controls to maximum gain (on amplifiers that have gain controls) and adjust levels with the OUTPUT controls of the TCX650.

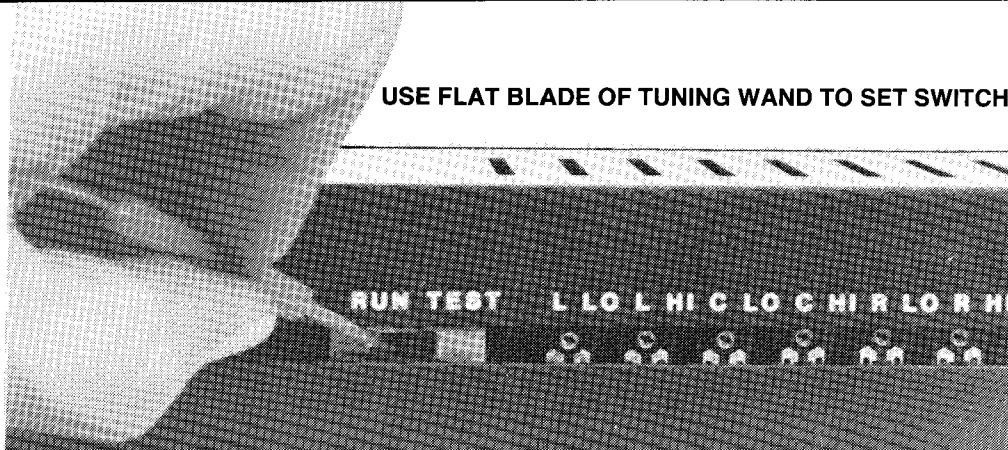
Before adjusting the OUTPUT controls, set the MASTER FADER of the Stereo Processor *in the proper operating range* (usually about 2 O'clock). The OUTPUT controls can be set for the proper level in the auditorium and still allow sufficient range of the MASTER FADER to accommodate normal differences in soundtrack level. This procedure will also allow the best signal-to-noise ratio of the processing equipment.

TURN ALL OUTPUT POTS TO MINIMUM (CCW)

With the Room Equalizer (EQ600 or similar equalizer) in the FLAT position, feed a *pink noise* signal into the Stereo Processor by using a film test loop as a source. Place the Real-Time Analyzer sensing microphone within 15 to 20 feet of the speaker being adjusted so that room reverberation effects are minimized. Raise the HF and LF OUTPUT until about 80 dB SPL is noted on the RTA screen. Note: Some RTA's don't have an SPL indicator. A sound pressure meter may be used with the RTA. Remember that the SPL will drop with distance. Remember that a pink noise loop is recorded about 18 dB lower than 100% modulation of a release print feature film. When you are through with the set-up of the TCX650, you must reduce the MASTER FADER to avoid driving the system to dangerous levels.

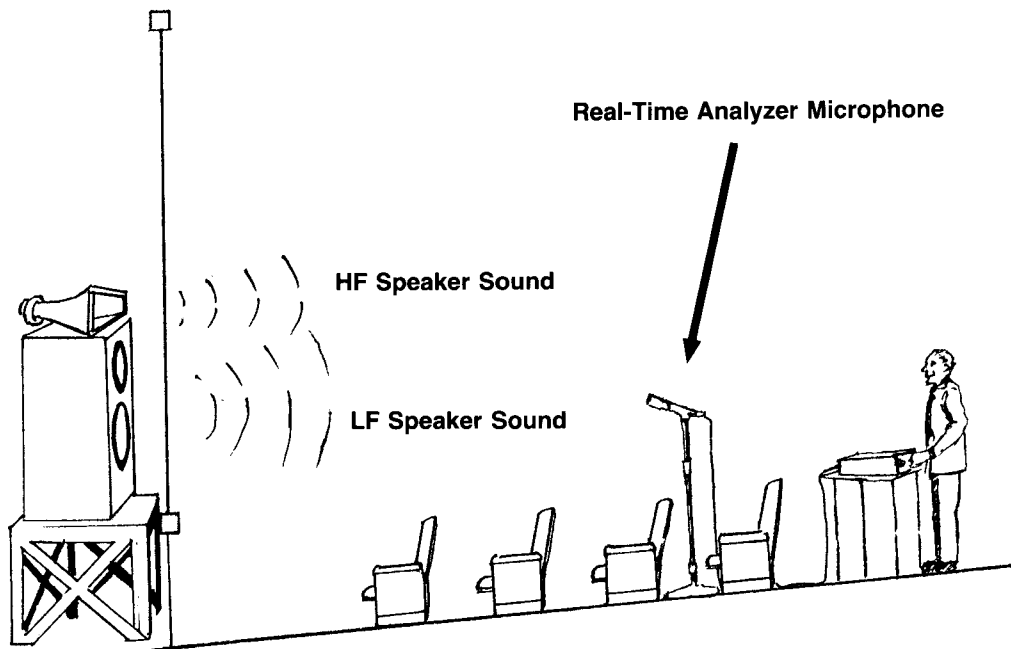
Both optical tracks of the Pink Noise loop are the same, and are in-phase. This will cause the matrix decoder in the SVA processor to send the signal to the CENTER CHANNEL of the stereo system. To avoid this action it is necessary to DISCONNECT one lead of the solar cell at the processor input terminals temporarily. If the LEFT cell is disconnected, you can set the RIGHT speaker for the smoothest crossover. Reconnect the LEFT cell wire and remove the RIGHT cell lead. Now adjust the LEFT channel. Turn off the LEFT-RIGHT power amplifiers (most theatre stereo systems use a dual power amplifier for the left and right channels), and adjust the center channel crossover.

Adjust the HF and LF controls for the smoothest response curve on the RTA screen. Do not be concerned with a dip or peak at the 500 Hz crossover band. This will be fixed when the Time-Phase correction is made. The overall response will be treated during the room equalization phase of the tuning. The important accomplishment during this phase of adjustment is that the speaker systems are properly balanced. It is not unusual to observe that the HF control is set to a lower level than the LF control. This is due to the fact that High Frequency loudspeaker drivers are more efficient than woofers.



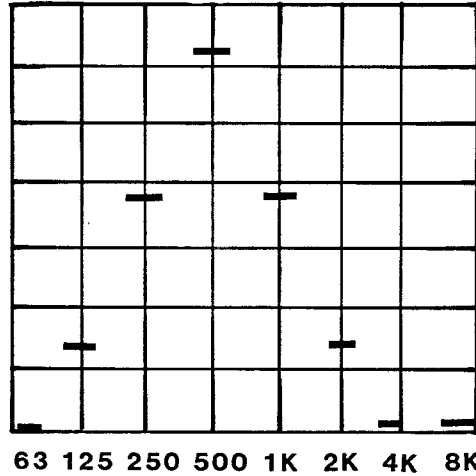
REMOVE THE TEST LOOP and switch the TEST-RUN switch that is located behind the front panel security cover to the TEST position. A 500 Hz tone will be sent to the *Center Stage Speaker ONLY* by the built-in tone oscillator.

TIME-PHASE DELAY ADJUSTMENT. Adjust the *DELAY* control until you observe the **HIGHEST PEAK** at 500 Hz on the RTA. It may be necessary to reverse the speaker leads to the HF driver in order to achieve a large peak. The peak indicates the best Time-Phase alignment between the HF and LF transducers. Since the tone generator produces a single tone of 500 HZ, the peak on the RTA should be very clearly seen. It is also possible to use an SPL meter to determine the peak, but it is not as easy to "fine tune" to the best peak possible. RETURN THE TEST SWITCH TO THE RUN POSITION.



TYPICAL PLACEMENT OF ANALYZER IN AUDITORIUM

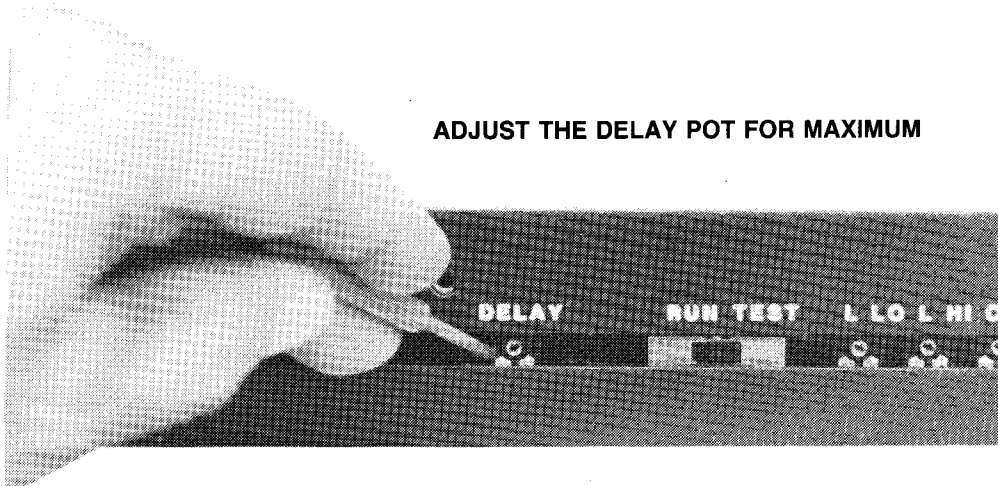
TCX650 Crossover



ADJUST FOR HIGHEST PEAK AT 500 HZ

It is only necessary to adjust the Center Channel Speaker system because the DELAY control moves the TIME-PHASE of *all three stage speaker simultaneously*. As long as all three speaker systems are the same model, and are mechanically aligned the same way, when the Time-Phase is correct for one, it is correct for all.

The RTA sensing microphone may now be moved to the portion of the auditorium where the room tuning will be performed using the house equalizer.



ADJUST THE DELAY POT FOR MAXIMUM

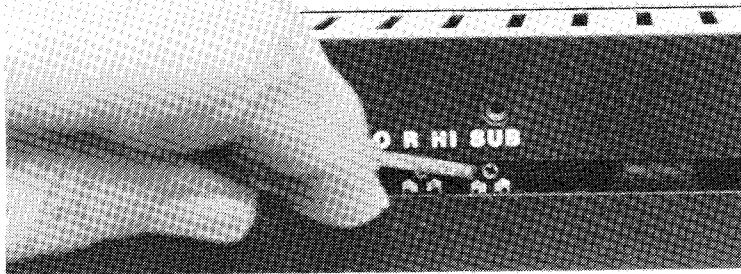
PEAK ON REAL-TIME SCREEN AT 500 HZ

SUB-WOOFER ADJUSTMENT. The control labeled SUB sets the proper level for a sub-woofer speaker system. The sub-bass circuit in the TCX650 contains all the necessary filtering so that the SUB output contains only deep bass information. This signal is derived from a sum of the LEFT and RIGHT stereo channel program information supplied by the other sections of the electronic crossover. Adjusting the SUB control will send a higher or lower signal output to a separate sub-woofer amplifier.

There is NO OUTPUT from the SUB terminals when *monaural material is passing through the TCX650*. The sub-woofer is only active when SVA Stereo, Synthesized Stereo, or Magnetic Stereo is being played through the system. Most mono soundtracks have bass boost added during recording, and a sub-woofer would overpower the audience if allowed to play.

Some Stereo Processors have optional BASS EXTENDER additions that must be purchased separately. If the system you are installing has one of these options, DO NOT USE the SUB output of the TCX650. Connect the sub-woofer system directly to the BASS EXTENDER option of the processor.

**SUB-WOOFER OUTPUT HAS MORE GAIN
THAN THE MAIN STAGE CHANNELS**



An alternative method of matching crossover levels is to insert a pink noise generator into an appropriate point of the system. The generator may be connected directly to the inputs of the TCX650. If another brand of processor is used, refer to the manufacturers recommendations.

OUTPUT MUTING. There are four (4) relays in the TCX650 for muting the output of each channel. These relays greatly reduce the turn-on “thump” in the stereo system when the system is turned on each day. A time delay circuit activates the relays about one second after turn on. This gives the other components in the system time to stabilize before an audio output can pass through the TCX650. If your system does not have a master AC power switch, turn the TCX650 on *LAST*.

The relays are a miniature type that plug into an IC socket. If a channel does not work when you receive the TCX650, check the seating of the relays in their socket. It is possible that the relays can vibrate during rough handling during shipping. A visual check of the relay motion is easily seen when the front panel power switch is activated. All four relays should move during turn-on and drop out during turn-off.

DELAY RANGE. The LF delay sections of the TCX650 has an adjustment range of 0.2 milliseconds to 1.2 milliseconds. This will produce a full 180° phase shift at 500 Hz, or anywhere in-between. If a perfect peak cannot be obtained on the RTA screen, reverse the HF driver leads and try again. It is possible that the transducers were near the extremes of the adjustable range of the shift.

INPUT LEVELS. The TCX650 is designed for unity gain operation. The recommended input level is 0 dBv with a maximum input of + 10 dBv before clipping. Do not overdrive the channels with too high an input level. If a SMART EQ600 is used prior to the TCX650 in the system, high levels may be adjusted at the output of the EQ600. The signal-to-noise ratio of this product is better than -80 dBm.

SERVICE

Almost every component in the EC650 and TCX650 Electronic Dividing Networks are available from a local radio parts house except the time delay chips and possibly the plug in relays. Refer to the schematic diagram for information regarding a component. When a "Poly" is specified, it refers to polyester (mylar) capacitors. A tantalum type capacitor should be replaced with a like kind.

Before performing a service call check the obvious:

1. Is the power L.E.D. indicating AC power to the unit?
2. Replace any blown fuses.
3. Are the panel switches in their operating positions?

A quick check of the power supply voltages will indicate the proper operating voltages for the active components. Place your service meter negative lead on a convenient chassis GROUND point. Switch the meter to the + 30 D.C. range and measure the voltage input to the POSITIVE regulator (pin 1). It should be 18-24 volts. Now measure the output of the regulator (pin 3). This voltage should be very close to + 15 volts. Now, do the same with the NEGATIVE regulator. Use the positive lead of your meter on the chassis GROUND, and the negative lead for voltage measurements. Pin 2 is the input to the regulator, and pin 3 is the output. Again, you should measure nearly -15 volts. If you cannot obtain the voltages mentioned, you could have a bad diode in the rectifier bridge, a shorted filter capacitor, or an open winding on the transformer. **BE CAREFUL NOT TO SHORT THE PINS ON THE REGULATORS WHILE MAKING THESE TESTS. A MOMENTARY SHORT COULD DESTROY THE IC REGULATORS.**

When you are satisfied that the voltages are correct, go to the section for the circuitry that appears to be giving trouble. The most practical way to troubleshoot audio circuits is through signal tracing. Put an audio signal into the input and follow the signal with a scope until the signal stops. This method allows you to locate a defective component in the related section.

Since the TCX650 and EC650 uses a bi-polar supply, each audio IC op-amp output should measure nearly 0 volts D.C. with no signal. That is, you should be able to probe each output pin with your service meter and see a minimum offset. If the op-amp is showing a few volts at the output pin, it is likely that a bad capacitor or resistor is causing an input bias that forces the output of the amplifier to shift. A defective IC could also be the culprit. Also check for a hairline short in the PC card foil traces. Here are several tips that will aid in troubleshooting.

1. Make sure the switches are in the proper position before testing the unit.
2. Very hot IC's usually indicate an internal short.
3. An open resistor may lead you to believe that an IC is defective. Use a substitute device to see if problem is in the device itself, or elsewhere.
4. Shorted input capacitors may bias an IC op-amp OFF.
5. Be sure IC's are firmly in their sockets. They can be vibrated loose during shipment.
6. Check to see that the output MUTING RELAYS are firmly seated in their sockets.

The circuit flow diagram in this manual will assist in understanding the vital sections of the product. Since the units have three (3) channels, sections are repeated for each channel.

Signal tracing procedures may also be employed when servicing the time delay portion of the LF outputs. A signal at the input, through the filter circuit, the delay chip, and the anti-alias filter will reveal where the signal has stopped. Refer to the schematic for pin identification of the signal flow. The internal clock associated with the MN3003 delay chip must be operating properly for the audio signal to

pass through the delay chip. If the internal clock fails, no audio can pass. We suggest you **DO NOT REMOVE** the delay chip itself unless you are positive it has failed. This component is very expensive, and can be easily destroyed by stray static caused by handling. The BIAS pots near the chips are factory set to each individual chip, and *should not be moved* unless the IC must be replaced by a new device.

This product uses a double sided PC card with plated through holes. The holes on the main PC card are easily damaged when service is attempted without the aid of the proper de-soldering equipment. Use proper tools to repair the PC board.

An important part of any pre-service call is to make sure that the operator or other theater personnel is fully familiar with the operation of this equipment. Often service calls are made un-necessarily because the operator was not trained with the correct operation procedures.



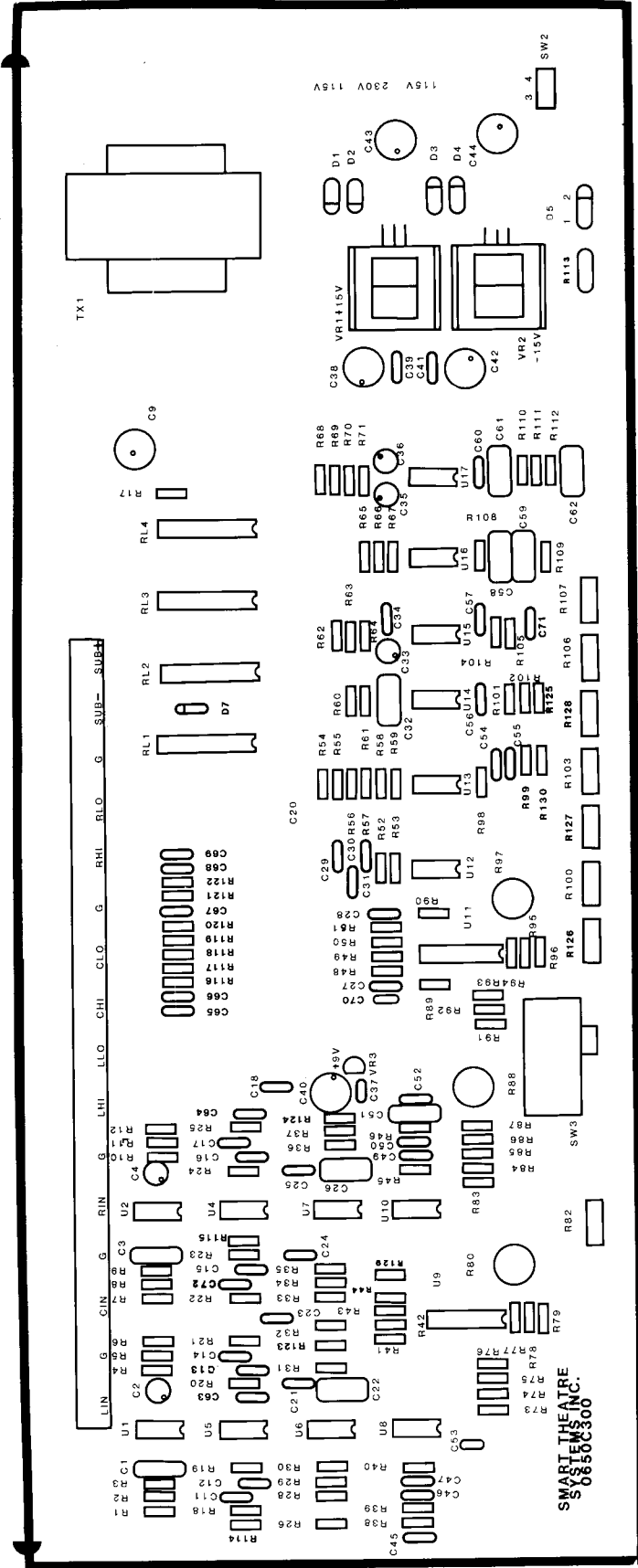
MANY IC DEVICES CAN BE DESTROYED BY HANDLING.

CMOS logic devices and Bi-FET Op Amps are very static sensitive. They are safe when plugged into their sockets, but removal can expose the inputs to conduct static electricity from tools, your hands, or other static generating components. **USE PROPER HANDLING PROCEDURES** when removing IC's from their sockets.

SMART THEATRE SYSTEMS maintains a factory service department that can provide quick handling of replacement parts, or telephone advice in the event of a problem in installation or service. SMART's toll-free telephone number for technical support is 1-(800)-45-SMART

We reserve the right to *make improvements* to our products without notice. If you have questions regarding updates that do not agree with the schematics in this manual, please contact us for additional information regarding circuit changes.

Refer to the schematic diagram at the end of this manual for component values and circuit wiring.



COMPONENT LAYOUT TCX650

0650C300

SERVICE

IMPORTANT



The lightning flash with arrowhead, within an equilateral triangle, is intended to alert the user of the presence of uninsulated "dangerous voltage" within the product's enclosure that may be of sufficient magnitude to constitute a risk of electric shock to persons.

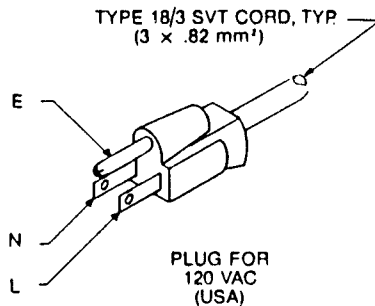
CAUTION

**RISK OF ELECTRIC SHOCK
DO NOT OPEN**

CAUTION:
TO PREVENT THE RISK OF ELECTRIC SHOCK, DO NOT REMOVE COVER (OR BACK). NO USER-SERVICEABLE PARTS INSIDE. REFER SERVICING TO QUALIFIED SERVICE PERSONNEL.



The exclamation point within an equilateral triangle is intended to alert the user of the presence of important operating and maintenance (servicing) instructions in the literature accompanying the appliance.



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

AC MAINS LINE CORD DETAIL

WARNING

Disconnect the power supplies from the AC power line before replacing components to avoid the danger of electrical shock.

