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FIRST THINGS

HERE IS YOUR MODULATION SCIENCES TELEVISION STEREO GENERATOR. PLEASE FOLLOW THE UNPACKING INSTRUCTIONS BELOW.

- ?? UNPACK THE UNIT AND SAVE ALL PACKAGING MATERIALS. YOU MAY NEED THEM LATER TO SHIP OR MOVE THE TSG.
- ?? INSPECT THE TSG FOR ANY SIGN OF DAMAGE.
- ?? IF YOU FIND ANY DAMAGE TO THE TSG, REPORT IT IMMEDIATELY TO BOTH THE CARRIER AND TO MODULATION SCIENCES.
- ?? IF THE TSG IS UNDAMAGED, FILL OUT THE REGISTRATION CARD YOU WILL FIND INSIDE THE FRONT COVER OF THIS MANUAL. RETURN THE BOTTOM HALF OF THE FORM TO MODULATION SCIENCES.

THE SCHEMATIC DRAWINGS THAT ARE PART OF THIS MANUAL ARE PROVIDED SEPARATELY AS FULL-SIZED SHEETS.

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Introduction

You will find Modulation Sciences' Television Stereo Generator (TSG) easy to install, easy to operate, and virtually trouble-free.

This manual will help you set up and use the TSG to broadcast the highest quality multichannel television sound possible.

The first chapter of the manual describes briefly the special features that make possible the TSG's high performance. Chapter Two lists the specifications for the unit.

The third chapter shows you in detail how to install the unit.

The next two chapters cover the essentials of routine operation and maintenance, followed by a chapter on field service. This section includes parts layouts and parts lists for the TSG.

Finally, there are several appendices designed to help you deal with special situations that may arise and enable you to align your equipment to produce the best possible stereo sound.

If you have any questions or comments, please call us on our toll-free line: (800) 826-2603.

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Chapter 1

Special Features

1.1 Designed “From the Ground” Up for MTS.

Modulation Sciences Television Stereo Generator is a complete system that integrates the baseband generator, BTSC encoder, filtering, audio processor, and monitor in one package—with each element working together by design.

The TSG is NOT a collection of random boxes designed at different times for different purposes.

Work began on the TSG design a few days after the December 1983 BTSC vote for the Zenith/dbx system. The first production models were delivered in October 1984.

1.2 Complies With BTSC (FCC OST-60, Revised) Standards.

The TSG meets or exceeds all of the standards for stereo multichannel television sound (MTS) as specified by the Broadcast Television Systems Committee (BTSC). These standards were adopted by the FCC in Office of Science and Technology (OST) Report 60, Revised.

1.3 Composite Output is Standard 75 Ohm Impedance.

The three composite outputs available to drive the exciters have sufficient current to allow termination of the far end with a 75 Ω load. Terminated coax may be used where ground loops are not a problem.

1.4 Balanced Composite Line Available as Option.

Where ground loop conditions preclude an unbalanced output, two optional balanced outputs are available. The TSG may be located as far as 3,000 cable feet from the aural exciter. Common-mode ground loop rejection is typically 100 dB.

1.5 Built-in Monitoring Facilities

All the monitoring functions needed for multichannel television sound operation are built into the TSG. Peak deviation of L+R, pilot, L-R, SAP, and PRO are available from the front panel of the TSG as well as remotely. The indications are “peak and hold” for easy, accurate reading locally or at the remote control site. These built-in functions eliminate the need for an expensive modulation monitor.

The FCC no longer requires that a modulation monitor be used, only that adequate means exist to maintain all parameters within specified limits. The TSG's metering meets this requirement.

Initial setup and performance verification require only a wideband aural demodulator, an RF spectrum analyzer, and an oscilloscope. This enables independent verification of the entire transmission system—TSG, aural exciter, transmitter, and diplexer.

1.6 Meters and Alarm Warn of Out-Of-Phase Audio.

Loss of audio to monaural listeners (conventional TV sets) from channel phase reversals will be a common start-up problem in new stereo TV studio installations. To minimize this problem, the TSG has both a phase meter and a phase alarm built in. The front panel phase meter (more correctly called a correlation meter) provides a continuous indication of the time relationship between left and right channels. An alarm circuit will close external contacts and light a front panel indicator if an actual reversal takes place.

1.7 Built-In Test Functions Simplify Setup.

A 0.02 dB wide window comparator drives LEDs which allow matching of the BTSC encoder's reference level to 100% modulation. This feature is especially convenient because failure to set the modulation sensitivity to exactly match the encoder reference level will seriously reduce separation.

Also, test switches on the stereo generator board enable the use of standard oscilloscope stereo patterns to verify performance of the generator.

1.8 Audio Inputs Accept Left and Right or Sum and Difference.

Modulation Sciences recommends that stereo audio be transmitted in discrete form (Left and Right). However, some television broadcasters prefer Sum (L+R) and Difference (L-R). The TSG will accept either format at its input terminals. The mode is selected by internal jumpers located on the audio input board.

1.9 Remote Control Metering

Fifteen channels of metering are provided. The selection of parameters is made by electronic switching that can be operated from the front panel or by remote control. A buffered zero to five volt output is available for remote readings.

1.10 Accepts Composite Video for Synchronizing Stereo to H Sync.

The BTSC standard requires that the pilot and L-R subcarrier be locked to horizontal sync. The TSG derives that lock from standard composite video—separate horizontal drive is not required. An industry standard video loop-through is provided.

1.11 Semi-Automatic Loudness Control

A semi-automatic level controller allows an operator to reduce levels without having to fight the audio processing. Two pulse control lines are used. Each time the “step” line is pulsed, the modulation level drops 0.5 dB. This enables an operator to rapidly drop the loudness of an offending spot. After the spot, the “reset” line is pulsed once and the attenuation slowly ramps back to zero. This is standard equipment with the TSG.

1.12 Remote Stereo On/Off and Relay Status Indication.

Local controls, as well as opto-isolated remote inputs, select stereo or monaural mode. When in monaural mode, on-board jumpers select either left or left-plus-right inputs to provide the mono signal.

1.13 Changes Automatically to Monaural Mode if Sync Is Lost.

If composite video is lost, the TSG automatically reverts to monaural mode. Operation in stereo without sync lock violates the BTSC standards.

1.14 Stereo Baseband Synthesized by Digital Techniques.

The TSG employs a modern digital synthesis technique to develop the stereo baseband. This method delivers maximum separation and spectral purity. Because it is digital, no internal trim adjustments are needed, thus ensuring long term stability.

1.15 Inputs for SAP and PRO Channels.

By routing the Second Audio Program and PRO channels through the TSG, precise mixing levels can be established. Metering built into the TSG allows monitoring of the injection level of these auxiliary signals without need for a modulation monitor.

1.16 dbx Licensed Technology? Optimum for Broadcast Encoding.

Modulation Sciences has a license from dbx, Inc. to manufacture BTSC encoder boards itself. Most other companies are dependent on dbx, Inc. to provide complete boards. This added flexibility ensures maximum broadcast performance from the BTSC noise reduction system as well as ensuring a steady supply of encoders.

1.17 Full Audio Processing Available as an Option.

The TSG has full audio processing available as an option. This is in addition to BTSC noise reduction encoding. The additional audio processing eliminates the need for stereo compressors and limiters before the TSG. The processing is state of the art, including noise gating, gain platform, and loudness control.

Chapter 2

Specifications

Size

Front Panel: 6.96" H x 19" W (177 mm H x 483 mm W)
Chassis: 6.96" H x 17" W x 14.37" D
(177 mm H x 432 mm W x 365 mm D)

Power

95 to 130 VAC, 50/60 Hz, 60 W maximum
190 to 260 VAC option available

Temperature Range

10° to 45° C

RF Protection

All inputs and outputs RF suppressed

Input/Output Connections

Audio Input

No. 6 screw terminals
0 to +10 dBm, balanced, 600 Ω
Discrete Left and Right or Sum and Difference

Remote Inputs

No. 6 screw terminals
6 to 24 VAC, 10 to 24 VDC
Floating, optically isolated

Composite Video In/Out

BNC connectors
Bridged loop through

External SAP and PRO Generator Inputs

BNC connectors

SAP: 3.5 V peak-to-peak produces ± 15 kHz peak deviation.

PRO: 3.5 V peak-to-peak produces ± 3 kHz peak deviation.

Remote Binary Outputs

No. 6 screw terminals

Isolated relay contacts

Maximum 0.5 A at 30 V non-inductive

Remote Meter Output

No. 6 screw terminals

0 to 5 VDC, 1K Ω source impedance

Composite Baseband Output

(for ± 73 kHz peak deviation):

Unbalanced BNC connector

0 to 8 V peak-to-peak, high Z load

0 to 4 V peak-to-peak, 75 Ω load

Balanced (Optional) Male XLR-type (two provided)

0 to 8 V peak-to-peak

78.7 Ω impedance, 124 Ω special order

Drives up to 2500 feet (762 m) of Belden 9463 twinaxial cable terminated with an optional MSI line receiver.

Indicators

Meter Channel

Tells which parameter is displayed on the D'Arsonval meter.

Attenuation

Loudness control attenuation in 0.5 dB steps.

Stereo

TSG is in stereo mode.

Mono

TSG is in mono mode.

Sync

Positive indication that video sync is being received and TSG is locked.

Stereo Rev

Alarm when one channel of incoming audio is reversed, causing monaural cancellation.

Fuse

Indicates primary AC fuse blown.

Ref Level LEDs

LEDs on BTSC encoder board for setting precise 100% reference level.

Controls (front panel)

Meter Select

Positions meter (as indicated by meter channel LEDs) on desired parameter.

Loudness Step

Each time it is pressed, program level is reduced 0.5 dB.

Loudness Reset

Smoothly restores the program level to normal after use of Loudness Step.

Mono/Stereo

Switches the TSG alternately between monaural and stereophonic operation.

Gate

Sets the threshold of gain expansion on quiet program material. Prevents "pumping."

HFR

Sets the threshold of broadband peak limiting.

Input Level

Sets the level of Left and Right audio into the TSG. If the input board is strapped for matrix input, sets Sum and Difference levels.

Typical Performance

Accuracy of 75 μ sec Pre-emphasis

± 0.1 dB

Stereo Subcarrier Suppression

Less than ± 100 Hz peak deviation of main carrier.

Frequency Response (all modes)

50 Hz, less than -0.5 dB

100 Hz to 14 kHz, ± 0.32 dB

Total Harmonic Distortion

At 25, 50, and 100% M channel modulation, Left or Right channel driven.
Bandwidth = 15 kHz, measured with 75 μ sec de-emphasis or BTSC decoding. L+R and L-R clippers disabled for 100% modulation BTSC measurements.

75 μ sec equivalent mode

50 Hz to 7500 Hz, less than .014%

BTSC encoded

50 Hz, less than .15%

100 Hz to 7500 Hz, less than .073%

Separation

75 μ sec equivalent mode

Greater than 50 dB, 50 Hz to 15 kHz.

BTSC encoded

Greater than 40 dB, 50 Hz to 14 kHz.

Crosstalk

Into main channel from L-R subcarrier: Greater than 79 dB below
 ± 25 kHz peak deviation.

Into L-R subcarrier from main channel: Greater than 61 dB below
 ± 50 kHz peak deviation.

Signal-To-Noise Ratio

Equivalent mode with 75 μ sec de-emphasis:

FM noise in main channel: Greater than 70 dB below
 \pm 25 kHz peak deviation.

FM noise in L-R subchannel (after demodulation):

Greater than 72 dB below \pm 50 kHz peak deviation.

Equivalent Input Noise Of BTSC Encoder

Greater than 83 dB below the 100 Hz 100% equivalent
modulation level.

Pilot Protection

Better than 35 dB in a bandwidth of 1 kHz, centered on the pilot.

NOTE: These specifications are based on typical measured performance.
Minimum performance will exceed BTSC specifications by a wide margin in all
cases.

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Chapter 3

Installation Procedure

You must read and thoroughly understand this section before you begin installing the TSG.

Preliminary Considerations

3.1 Audio Input Connections

3.1.1 The audio inputs are electronically balanced and have excellent common mode rejection. The inputs are normally terminated in 600 Ω resistance, but they may be converted to bridging. See Chapter 3, Section 4.2.

3.1.2 The TSG is factory supplied for Left and Right audio inputs. A strap option on the "F" card (see Chapter 3, Section 4.4) permits driving the TSG with sum and difference. However, Modulation Sciences does not recommend sum and difference audio distribution.

3.1.3 On Terminal Strip 1, terminals 1 (+) and 2 (-) are the balanced input connections for the LEFT AUDIO (or SUM AUDIO) and terminal 3 (GND) is the ground connection for the shield. Similarly, terminals 4 (+), 5 (-), and 6 (GND) are for RIGHT AUDIO (or DIFFERENCE AUDIO).

3.1.4 The maximum peak audio level for these inputs is +20dBm. Program level should be between -10 VU and +4 VU (0 VU = 0 dBm sine wave) for optimum operation of the audio processor. Program levels up to +8 VU can be accommodated, but the full gain control range of the processor cannot be used if this is the case. The tradeoffs involved are explained further in Chapter 4 ,section 8.0, "Adjustment of Audio Processor Controls."

3.2 Synchronization to Video

3.2.1 The BTSC standard requires that the stereo pilot be synchronized with the horizontal sync signal. Connect composite video to the VIDEO BNC connectors on the back panel marked "IN." The level of the video signal is 100 IRE. The other VIDEO BNC must be connected to a 75 Ω termination, either at the generator or through a length of cable. This is a loop-through connection.

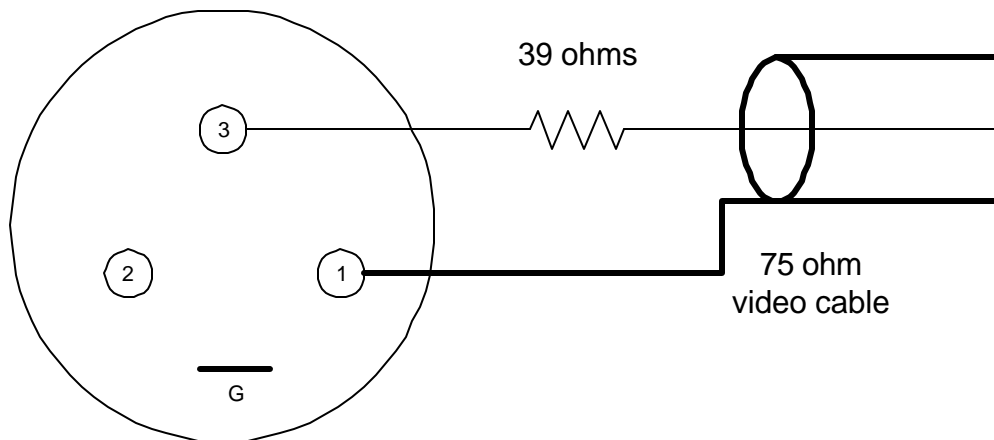
3.2.2 In the event that sync is lost, the TSG will automatically switch to the MONO mode and the SYNC LOSS ALARM contacts (terminals 5 and 6 on terminal strip 3) will close. In addition, the STEREO INDICATOR contacts on terminal strip 3 will open to indicate MONO mode.

3.3 Composite Output

3.3.1 Composite baseband output is provided at two 3-pin "XLR"-type connectors and at the COMPOSITE OUTPUT BNC connector.

3.3.2 For short runs, you may use the BNC connector and 75 Ω foil shielded coax or video cable terminated at the exciter. If you encounter moderate amounts of ground loop noise, try a video hum-stop coil in the composite coax. If you use good quality video coax, cable lengths up to 100 feet should produce acceptable results, provided ground loop problems are not too severe.

3.3.3 For longer runs, or where ground loop noise is severe, use a balanced output. Use balanced, shielded cable such as Belden Type 9463 Twinax in conjunction with the MODULATION SCIENCES CLD-2503 balanced receiver or feed directly into your transmitter if it has a balanced composite input. To maintain spectral purity and stereo separation, it is absolutely essential that you maintain proper impedance levels and shield integrity. The Modulation Sciences CLD-2503 with Belden Type 9463 cable is the recommended solution for cable lengths up to 2500 feet. Longer runs are possible with other cable types. Call Modulation Sciences for details.



Switchcraft A3F
XLR Connector
or equivalent

Figure 3-1A
Single Additional Output

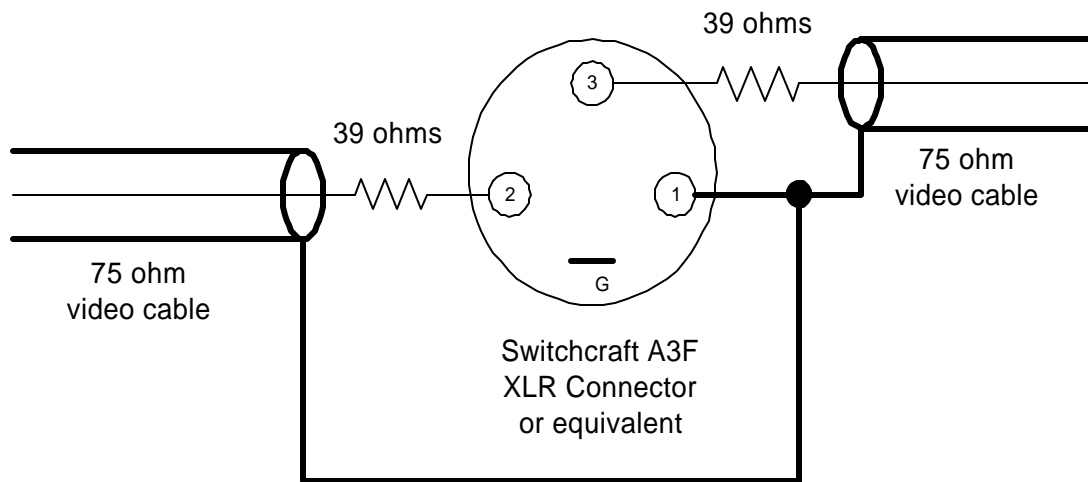


Figure 3-1B
Dual Additional Outputs

3.3.4 The balanced output connectors may be connected to alternatively provide multiple unbalanced outputs. A standard TSG (without the balanced output option) will provide two additional unbalanced outputs. Standard XLR connectors may be used as shown in Figure 3-1A to provide the additional outputs. When the balanced output option is installed, the balanced output connectors can provide four additional unbalanced outputs. Each XLR connector can now drive two 75 Ω coaxial cables. See Figure 3-1B. (ICs U12 and U14 on the "G" card must be installed to provide the balanced output option.)

3.4 Remote Control Inputs

The TSG is provided with the following remote control inputs on terminal strip 2. All remote control inputs are floating, diode protected, and optically isolated. They will operate from either 6 to 24 VAC or 10 to 24 VDC. If you use DC, observe the polarity markings for proper operation. Input impedance is 2.7 k Ω . Control pulses should be at least 100 milliseconds long.

3.4.1 Stereo On

Terminals 1 (+) and 2 (-) cause the generator to switch into STEREO mode.

3.4.2 Stereo Off

Terminals 3 (+) and 4 (-) cause the generator to switch into MONO mode.

3.4.3 Loudness Step

Terminals 5 (+) and 6 (-) cause the modulation level to be reduced by 0.5 dB each time the input is pulsed.

NOTE: Loudness control is available only if the audio processor option is installed.

3.4.4 Loudness Reset

Terminals 7 (+) and 8 (-) cause the modulation level to be restored to 100%.

3.4.5 Meter Step

Terminals 9 (+) and 10 (-) cause the meter function to advance to the next function to the right as you face the front panel.

3.4.6 Meter Reset

Terminals 11 (+) and 12 (-) cause the meter function to reset to the TOTAL MODULATION position.

3.5 Remote Control Status And Alarm Outputs

The TSG is provided with the following indicator and alarm outputs on terminal strip 3. These outputs are isolated, floating relay contacts rated at 0.5 Amperes, 30 V, non-inductive load. Do not attempt to switch 117 VAC directly with these contacts. Caution must also be exercised with incandescent lamp loads. Do not switch any lamp that draws more than 50 mA.

3.5.1 Stereo Indicator

Terminals 1 and 2 close whenever the generator is in the stereo mode.

3.5.2 Stereo Reverse

Terminals 3 and 4 close if the L/R CORRELATION circuit detects a polarity reversal of either Left or Right audio.

3.5.3 Sync Loss Alarm

Terminals 5 and 6 close when synchronization to "H" (the horizontal sync signal) is lost.

3.6 Meter Output

3.6.1 Terminals 7 (+) and 8 (G) on terminal strip 3 are used to connect to a remote metering device. The meter drive circuit provides a fast attack, peak hold, and a slow release. This allows a remote control metering system with a low sampling rate to transmit meaningful data to the studio about rapidly fluctuating parameters such as modulation.

3.6.2 An open-circuit voltage of 5 V corresponds to a reading of 100% on the front panel meter. Output impedance is 1000 Ω . Load resistance must be 1000 Ω or greater and load capacitance must be less than 0.01 microfarads.

3.6.3 A 0 to 1 mA meter movement may be driven directly via shielded cable up to 100 feet long if an appropriate resistor network is used at the meter. A resistor should be provided in parallel with the meter movement so that the pointer movement is properly damped and a series trimpot should be provided to allow calibration of the external meter to the front panel meter on the TSG. Modulation Sciences can supply connection details and meter movements with the correct scale if you need them.

3.7 Test Equipment Required

The few pieces of test equipment listed below are all you will need to install the TSG:

1. An audio oscillator capable of +8 dBm output into 600 Ω , with THD of 0.1% or less.
2. A sine wave source with a frequency accuracy of 10,396 Hz, ± 1 Hz.
A Tektronix 1405 Sideband Adaptor provides this as one of its output signals. Alternatively, the audio oscillator listed above may be used with a frequency counter to measure the oscillator frequency.
3. An accurate digital AC voltmeter, preferably one with a relative dB scale.
Many inexpensive hand-held digital multimeters have these features. Many have built-in frequency counters.
4. An RF spectrum analyzer, such as a Tektronix 7L12 or 7L13, or some other method of measuring the aural carrier level in the presence of modulation.
See Appendix A for options other than an RF spectrum analyzer.
5. An oscilloscope will be useful if one is available, but it is not essential for installing the TSG.

IF YOU HAVE NOT ALREADY READ
THE PRECEDING PAGES OF THIS
SECTION TITLED
“PRELIMINARY CONSIDERATIONS,”
READ THEM NOW
BEFORE YOU BEGIN
THE INSTALLATION PROCEDURE.

3.8 Introduction

3.8.1 The TSG should be installed at the transmitter site. Various schemes exist for locating the TSG in the studio, but none have been demonstrated to work very well. The demands on noise, gain/phase, and modulation sensitivity and stability performance exceed what is now available from a subcarrier above video.

3.8.2 If the TSG **must** be located at the studio, a composite aural STL commonly used in FM broadcasting is your best bet. The Moseley Associates wideband composite STL should work.

3.8.3 We recommend rack-mounting the TSG at the transmitter site and locating it where it will not be subject to extremes of temperature. The most desirable location is in a quiet area where good stereo audio monitoring is available, making it easier for you to judge the subjective adjustments of the audio processor. If you can mount the unit at eye level, the adjustments will be much more convenient.

3.8.4 Mounting the TSG as close to the aural exciter as possible is desirable to minimize ground loops, but don't sacrifice convenience of setup for this proximity. If ground loop problems should appear, there are several remedies. See Appendix B.

In any case, the interconnecting coax should be video cable or foil-shielded CATV-grade cable. Do not use simple braided coax such as RG-59 which will not provide adequate RF suppression.

3.8.5 If the transmitter site is remote controlled, connect the TSG to the remote control. You need only one raise/lower control and one metering channel to monitor all 15 meter functions.

All three status outputs are useful—Stereo On, Stereo Reverse, and Sync Loss. However, if you have only one remote alarm channel available, use it for the Stereo Reverse. (A local audible alarm is also desirable.)

Stereo reversals are the single most common cause of grief in new stereo installations. They can be introduced anywhere in the audio system. Their effect is devastating because audio is cancelled to conventional (monaural) TV set users.

3.9 Make Sure PC Cards Are Properly Seated

3.9.1 Check to be sure that all of the printed circuit cards in the TSG are seated properly. Occasionally, a card can be jarred out of position during shipping. For access to the cards:

1. Be sure the TSG is turned off.
2. Loosen the two quarter-turn screw fasteners and lower the front panel.
3. Remove five (5) Phillips screws and loosen the slotted screw in the lower right-hand corner of the front shield plate.
4. Remove the shield plate.

3.9.2 Slide each card out an inch or two. Make sure it is in its card guide and push it back in until it connects again.

3.9.3 Reverse steps 2, 3, and 4 above to re-assemble the TSG.

3.10 Hookup

You are now ready to begin the actual installation procedure.

3.10.1 Mount the TSG in a rack using four rack screws.

3.10.2 Hook up standard composite video (100 IRE) to the Video "IN" BNC. Hook up a 75 Ω termination or properly terminated 75 Ω coax to the "VIDEO OUT" BNC connector. This is a loop-through connection.

3.10.3 Connect the TSG COMPOSITE OUTPUT to the aural exciter wideband input via 75 Ω foil-shielded coax or video cable. Be certain that the exciter provides termination. If the TSG is fed from its own DA output, simply terminate the unused loop-through connector in 75 Ω .

3.10.4 Connect Left and Right audio to the TSG's audio inputs using two-conductor shielded cable. Foil-shielded cable such as Belden 8451 is preferred. For best RF immunity, the cable shield should be connected to ground at both ends. If you have an audio ground loop problem, lift the shield at the source end, not at the TSG.

3.10.5 Connect the line cord to a 120 VAC grounded outlet. (Using the same AC feed as the exciter may help eliminate ground loops.) Look at the front control panel. The meter light should light, meter mode should be TOTAL MOD, and LOUDNESS display should light and indicate "0.0". The SYNC LED will light if video is present. If the SYNC LED is on, the TSG should be in STEREO mode. If the SYNC LED is not on, the TSG will be forced into MONO mode.

3.11 Reference Level Setup

3.11.1 Connect your 10,396 Hz sine wave source to the LEFT AUDIO input. Use the Tektronix 1405 if you have one. If the TSG's mono audio mode is set to L ONLY (the factory setting), do not apply a signal to the RIGHT AUDIO input. If the mono audio mode is set to L+R, apply the signal to both audio inputs. Section 3.17.3 of this chapter describes how to change the mono audio mode.

3.11.2 If the oscillator output is unbalanced, connect its output to (+) on the TSG and connect its ground to (-) as well as to the GND terminal. The cable shield should always be connected to the GND terminal on the TSG.

3.11.3 If you are using a variable-frequency sine wave oscillator, use a frequency counter to set it to *exactly* 10,396 Hz.

3.11.4 Set the oscillator level near its maximum output, but no higher than +8 dBm.

3.11.5 On the front panel, set the selector to MONO mode. It may be a good idea to remove the video sync from the TSG to ensure that the TSG remains in the monaural mode. Loosen the two quarter-turn screw fasteners at either end of the front panel and lower the front panel to expose the RF shield panel. If the TSG is on a bench rather than in a rack, be certain that the front panel buttons do not accidentally operate when the front panel rests on the bench. Bypass the BTSC card (switch on “D” card up). On the “A” card, be sure that S1 is set to BYPASS and S2 is set to FLAT (both switches up). If the audio processor option is not installed, S1 will not be present—ignore all references to it.

3.11.6 Perform this step *only* if the mono audio mode is set to L+R. *Skip this step* if the mono audio mode is Left Only (the factory setting). Set the meter selector to R AUDIO and adjust the RIGHT INPUT LEVEL control so that the meter reads 100%.

3.11.7 Set the meter selector to L+R MODULATION. Using the LEFT INPUT LEVEL pot on the “F” card, turn it clockwise to adjust the L+R MODULATION to a reading of approximately 100% on the top scale of the meter. As the level increases, the **green** LED on the “D” card will light and the **red** LED will light at a slightly higher signal level. Turn up the pot (CW) until the **red** LED lights, then adjust the pot (CCW) until only the **green** LED is lit. Be certain that the TSG is in the MONAURAL mode.

3.11.8 Note: If both the **green** and **red** LEDs go on and off together, or if either one flashes randomly, there is either excessive noise on the oscillator output or the oscillator’s level stability may not be adequate. The **green** and **red** LED drive circuit is a precision level sensor with an amplitude range of only 0.02 dB. A ground loop between the oscillator and TSG is the most common cause of trouble.

Standard cures for a ground loop include plugging the oscillator into the same AC outlet as the TSG, floating the AC ground pin on the oscillator or alternately floating or grounding the low side of the oscillator output. However, the most effective solution is to balance the output of the oscillator using a good quality, well shielded 1:1 audio transformer. A Western Electric 111C repeat coil found in old style Telco line equalizers is excellent for this purpose.

3.12 Bessel Alignment — Exciter With Input Level Control

If the aural exciter has an input level control, follow this section. If your aural exciter does not have an input level control for its wideband input, use the procedure described in Section 3.13 of this chapter.

3.12.1 Set the COMPOSITE LEVEL trimpot on the “G” card fully clockwise until the output level is maximum. You will hear and feel a click when you reach this point. Then, back off the level by turning the pot three turns counterclockwise. Use a BNC “T” adaptor at the TSG’s COMPOSITE OUTPUT to verify the output level. Composite output level should be approximately 0.6 V RMS (1.7 V peak-to-peak), assuming that the exciter input impedance is 75 Ω . If the composite output is driving a high impedance load, the output level will be 1.2 V RMS (3.4 V peak-to-peak). When alignment is completed, this level should produce ± 25 kHz deviation of the transmitter.

3.12.2 From here on, make all level adjustments with the control on the exciter unless it lacks sufficient resolution for fine adjustments. In that case, do the final tweaking with the 20-turn COMPOSITE LEVEL trimpot on the “G” card.

3.12.3 Set up your RF spectrum analyzer to observe the aural carrier. If you do not have a spectrum analyzer available, turn to Appendix A and follow the alternate Bessel null procedure there. The analyzer should be adjusted to a narrow enough bandwidth to make it easy to separate sidebands 10 kHz apart. The vertical display should be 10 dB per division. Temporarily remove the aural modulation to be certain that the carrier itself is centered on the display.

3.12.4 Turn the exciter composite input level control to zero. Gradually increase the input level until the first null of the aural carrier is observed. The bottom of the null is exactly 25 kHz deviation or 100% M channel modulation. Because many exciter input controls do not have sufficient resolution for a precise setting, you may find it necessary to finish “tweaking” the null with the 20-turn COMPOSITE LEVEL control on the “G” card.

It is VERY important that the adjustment be to the FIRST null. A monaural or BTSC modulation monitor can serve to verify that the modulation is approximately 100% (? 25 kHz deviation). Do not expect the monitor to read exactly 100%, as the Bessel null procedure is far more accurate than any monitor.

Using a modulation monitor here serves only to check the setup and assure you that all levels are approximately correct. No modulation monitor, even if designed for BTSC, is sufficiently accurate to replace the Bessel null procedure described above.

3.13 Bessel Alignment — Exciter With No Input Level Control

For aural exciters that do not have an input level control, use the following procedure:

3.13.1 Using the composite output level control on the TSG, adjust the transmitter to approximately ± 25 kHz deviation (100% monaural modulation) using a conventional modulation monitor.

Using a modulation monitor here serves only to “rough in” the adjustment and assure you that all levels are approximately correct. No modulation monitor, even if designed for BTSC service, is sufficiently accurate to replace the Bessel null procedure described below.

3.13.2 Monitor the TSG’s output level at the COMPOSITE OUTPUT BNC connector using a “T” adaptor. The meter can either be a wideband AC voltmeter or an oscilloscope. If the composite output level is less than 0.6 V RMS or 1.7 V peak-to-peak (assuming an exciter termination of 75 Ω), attenuation should be added at the exciter end of the cable. The simplest technique is to use 75 Ω RF-grade attenuators. If you choose to add a trimpot to your exciter, it must be carbon or conductive film. A wirewound control of any type may seriously degrade the performance of your stereo signal.

If you have added attenuation at the exciter, go back and repeat the rough composite level setup above.

3.13.3 Set up your RF spectrum analyzer to observe the aural carrier. If you do not have a spectrum analyzer available, turn to Appendix A and follow the alternate Bessel null procedure there. The analyzer should be adjusted to a narrow enough bandwidth to make it easy to separate sidebands 10 kHz apart. The vertical display should be 10 dB per division. Remove the aural modulation to be certain that the carrier itself is centered on the display.

3.13.4 Turn the COMPOSITE LEVEL control on the TSG to zero. Then, gradually increase the level until the first null of the aural carrier is observed. The bottom of the null is at exactly ± 25 kHz deviation or 100% M channel modulation.

It is **very** important that the adjustment be to the FIRST null. The existing monaural modulation monitor can serve to verify that the modulation is approximately 100% (± 25 kHz deviation). Do not expect the monitor to read exactly 100%, as the Bessel null procedure is far more accurate than any monitor.

3.14 Audio Setup Procedure With TSG Audio Processor

3.14.1 Set the frequency of the audio oscillator to about 300 Hz. Apply the signal to both LEFT AUDIO and RIGHT AUDIO inputs.

3.14.2 On the RF shield panel, set the switches on the "A" card to BYPASS and 75 MICROSECOND. Set the switches on all other cards to the down position. On the front panel, put the unit into STEREO mode. Set the meter to the L AUDIO position. Adjust the LEFT INPUT LEVEL pot so that the TSG meter reading on the middle scale is at -2. Now set the meter selector to R AUDIO. Adjust the RIGHT INPUT LEVEL pot until the meter reads -2. Finally, set the meter to L-R AUDIO +20 dB and adjust the RIGHT INPUT LEVEL pot for a minimum reading on the meter.

3.14.3 Remove the audio oscillator and terminate both audio inputs with a short. On the front panel, put the unit into the MONO mode. On the RF shield panel, S1 on the "A" card should still be set to BYPASS (switch up) and all other switches should be in the down position. Observe the zero signal modulation level with a conventional monaural modulation monitor or other demodulator and measure the noise level on a meter with VU ballistics.

According to FCC/OST 60, Section (C)(a)(13), "The aural transmitting system output frequency modulation noise level in the band of 50 to 15,000 Hz (with de-emphasis) must be at least 58 dB below the audio level representing a frequency deviation of ± 25 kHz." If there is an excessive amount of hum or buzz, there are probably ground loops. For remedies, see Appendix B, "Eliminating Hum and Noise."

3.14.4 Switch the unit to the STEREO mode. Reset S1 on the “A” card to the NORM (down) position. Set the controls on the “A” card as follows:

GATE	12 O'clock
HFR	6 O'clock
LIMIT	12 O'clock

These settings should be satisfactory for most types of television audio. After you have completed this installation procedure, you may want to read Chapter 4, Sections 7.0 and 8.0 for a detailed description of what these three controls do.

3.14.5 Apply mono program material at normal operating level to both LEFT AUDIO and RIGHT AUDIO inputs. The signal at both inputs must be identical. If a stereo synthesizer is in use, mono on Left and Right can be generated by simply switching the synthesizer to mono. Switch the meter to GR. The meter reading should be about halfway between center scale and full left. If it is not, the INPUT LEVEL pots must be readjusted. Meter readings very far left of center scale indicate that the program level is higher than optimum and readings to the far right of center scale or that hover around center scale indicate that the program level is too low. Adjust both input pots equally to get the desired GR reading.

Switch the meter to L-R AUDIO. Adjust the RIGHT INPUT LEVEL pot for a minimum reading on the meter. Once the meter reading is below -20, switch to the L-R AUDIO +20 dB meter position for increased sensitivity and continue the null adjustment. The LEFT and RIGHT INPUT LEVEL pots are now properly set. If you cannot obtain a sharp null, there probably is significant phase shift between the Left and Right audio channels driving the TSG. Return to the GR meter position and repeat the adjustments.

3.14.6 You're all finished. Raise the front panel and tighten the two quarter-turn screw fasteners. You can begin normal operations with stereo sound. To verify the performance through the transmitter and diplexer, see Appendix C.

3.15 Audio Setup Procedure With External Audio Processor

3.15.1 If you are using a separate audio processor, you must determine what its peak output level is. If the processor's output level is adjustable, you should decide what its peak output level will be. We recommend +12 dBm. **Note:** This is true peak level as would be indicated on a PPM, not the maximum reading of a VU meter.

3.15.2 Set the frequency of the audio oscillator to about 300 Hz. Apply the signal to both LEFT AUDIO and RIGHT AUDIO inputs of the TSG. Set the level to +12 dBm or to the peak level produced by the processor if the processor's output is not adjustable.

3.15.3 On the RF shield panel, set all switches to the down position. On the front panel, put the unit into STEREO mode. Set the meter to the L AUDIO position. Adjust the LEFT INPUT LEVEL pot for a reading of 0 on the middle meter scale. Now set the meter selector to R AUDIO. Adjust the RIGHT INPUT LEVEL pot until the meter reads 0. Finally, set the meter to L-R AUDIO +20 dB and adjust the RIGHT INPUT LEVEL pot for a minimum reading on the meter.

3.15.4 Remove the audio oscillator and terminate both audio inputs with a short. On the front panel, put the unit into MONO mode. On the RF shield panel, all switches should be in the down position. Observe the zero signal modulation level with a conventional monaural modulation monitor or other demodulator and measure the noise level on a meter with VU ballistics.

According to FCC/OST 60, Section (C)(a)(13), "The aural transmitting system output frequency modulation noise level in the band of 50 to 15,000 Hz (with de-emphasis) must be at least 58 dB below the audio level representing a frequency deviation of ± 25 kHz". If there is an excessive amount of hum or buzz, there are probably ground loops. For remedies, see Appendix B, "Eliminating Hum and Noise."

3.15.5 Connect the audio processor to the TSG. Switch the TSG to STEREO mode. If the external audio processor provides pre-emphasized output, set the switch on the "A" card in the TSG to FLAT. Otherwise, set it to 75 MICROSECOND.

3.15.6 Apply mono program material at normal operating level to both left and right inputs of the audio processor. The signal at both inputs must be identical. If a stereo synthesizer is in use, mono on left and right can be generated by simply switching the synthesizer to mono. Adjust the processor for proper operation according to its manufacturer's instructions.

3.15.7 Set the TSG's meter selector to L AUDIO. Adjust the left channel output level of the audio processor so that peaks just reach 0 on the TSG's meter. Set the TSG's meter to R AUDIO and do the same for the right channel.

3.15.8 Switch the meter to L-R AUDIO. Adjust the right channel output of the audio processor for a minimum reading on the TSG's meter. Once the meter reading is below -20, switch to the L-R AUDIO +20 dB meter position for increased sensitivity and continue the null adjustment. If you cannot obtain a sharp null, there probably is significant phase shift between the Left and Right audio channels driving the TSG. Audio processors with independent high frequency limiters in the left and right channels can also cause this symptom.

3.15.9 Set the TSG's meter to L+R AUDIO. With normal program material, peaks should just reach 0 on the middle meter scale. The "D" card has clippers in both the L+R and L-R channels which are factory set to 90% continuous modulation. The L+R AUDIO reading is a good indication of how much clipping is taking place. A reading of 0 indicates about 1 dB of clipping.

Whether 1 dB of clipping is satisfactory depends on the nature and adjustment of the audio processor. If considerable limiting and clipping has already occurred before the signal gets to the TSG, even 1 dB of clipping may be too much. Listen to your broadcast signal, paying particular attention to sibilants in speech and high-frequency components in music. If you hear distortion which corresponds to the peaks you can see on the TSG's meter, you should lower the output level of the audio processor. Repeat the above procedure, setting the levels to -1 instead of 0. This adjustment is quite critical—a 1 dB change can make a considerable difference in the quality of the signal.

3.15.10 Total modulation should also be checked using stereo program material. Set the TSG's meter to TOTAL MODULATION and turn off SAP and PRO subcarriers if present. With normal stereo program material, frequent peaks should not exceed 75% on the top meter scale. (This corresponds to a peak deviation of 75 kHz.) In the BTSC system, the peak deviation of the stereo signal depends on a number of factors, including the width of the stereo image and the spectral content of the signal. The worst case is usually a very wide image with lots of high frequencies. If you observe frequent TOTAL MODULATION peaks in excess of 75% with the type of program material you plan to broadcast, you will need to reduce the output level of the audio processor to hold these peaks to 75%, even if this brings the L+R AUDIO reading somewhat below 0.

You may need to observe the TOTAL MODULATION reading over a period of time to determine whether any adjustment is required. If you are using SAP and/or PRO subcarriers, you can determine the allowable TOTAL MODULATION reading including the subcarrier(s) from Chapter 4, Section 5.0.

3.15.11 You're all finished. Raise the front panel and tighten the two quarter-turn screw fasteners. You can begin normal operations with stereo sound. To verify the performance through the transmitter and diplexer, see Appendix C.

3.16 Troubleshooting

If the TSG is not performing up to specifications, it is unlikely there is a malfunction with the unit itself. Each TSG is thoroughly tested before it leaves our factory.

If there is a problem, it may be the result of not following the installation procedure precisely. As the first step in troubleshooting, we urge you to carefully review the installation procedure step-by-step.

If this does not solve your problem, please refer to Appendices B, C, and D. Each of these outlines a problem which might prevent optimum performance and offers a solution for it.

Finally, we have a toll free number: (800) 826-2603. Call us and one of our senior engineers will discuss your problem with you and make recommendations for solving it.

3.17 Option Jumpers, Straps, And Adjustments

The TSG is designed to provide several options other than the factory settings for the unit. These options are exercised by the use of jumpers, straps, and trimpots on the printed circuit cards. In the following tables, the factory setting for each option is indicated by *.

3.17.1 Access To Printed Circuit Cards

1. Make sure the TSG is turned off. Unplug the unit or remove the fuse.
2. Loosen the two quarter-turn screw fasteners and lower the front panel.
3. Remove five (5) Phillips screws and loosen the slotted screw in the lower right-hand corner of the front shield plate.
4. Remove the shield plate.
5. Reverse the above procedure after changes have been completed.

3.17.2 Audio Inputs Terminated Or Bridging (“F” Card)

The audio input impedance is normally 600 Ω resistive. The terminating resistors may be removed if bridging inputs are desired.

Mode	J101	J201
Inputs Terminated	Installed*	Installed*
Inputs Bridging	Removed	Removed

3.17.3 Mono Audio Mode (“F” Card)

When the TSG is in MONO mode, the monaural audio may be either the LEFT AUDIO input only or the sum of the LEFT AUDIO and RIGHT AUDIO inputs. The LEFT ONLY mode is preferred, especially for new stereo conversions. In the event an audio polarity reversal (out of phase condition) takes place, monaural modulation can be restored by switching to mono mode. If mono audio is L+R, switching to mono mode will not restore modulation.

Mode	PS1 Jumper
Mono Audio L only	2 to 3*
Mono Audio L+R	1 to 2

3.17.4 AUDIO INPUT LEFT and RIGHT or SUM and DIFFERENCE (“F” Card)

Modulation Sciences recommends that stereo audio be in LEFT and RIGHT form. The TSG is factory set to accept this type of input. It may also be set to accept SUM and DIFFERENCE audio input.

Mode	PS101 Strap	PS201 Strap
Left/Right	1 to 2*	1 to 2*
Sum/Difference	2 to 3	2 to 3

3.17.5 Stereo Reverse Alarm Threshold Adjustment (“F” Card)

If the stereo reverse alarm trips on program material that you feel is acceptable, make the threshold more negative. The stereo reverse alarm threshold is adjusted by trimpot RV1 on the “F” card. The threshold is factory set to -0.85 on the L/R CORR meter (bottom scale). It can be adjusted from about 0 (RV1 fully CCW) to -0.70 (RV1 fully CW). The factory setting of -0.85 is at the center of the pot’s rotation. The adjustment is linear, allowing easy visual setting of the pot for intermediate values.

3.17.6 Audio Processor Normal or Limiter Only (“A” Card)

The audio processor card normally performs both as a level controller and as a limiter. If another audio processor is used ahead of the TSG — for instance, at the studio to protect the STL — it may be desirable to use only the limiter function to protect against overmodulation.

Mode	PS2 Jumper	PS3 Jumper
Full Audio Processing	2 to 3 *	2 to 3 *
Limiter Only	1 to 2	1 to 2

* = factory default mode

3.17.7 L+R And L-R Clippers In Or Out (“D” Card)

Both the L+R and L-R channels normally have clippers to prevent overmodulation in BTSC mode. The clippers are switched out when the TSG is in EQUIVALENT mode (“D” card set to BYPASS). Jumpers are provided to bypass the clippers in BTSC mode so that tests can be made at high modulation levels. To maintain proper BTSC separation, both clippers should be either IN or OUT. If only one clipper is jumped OUT, BTSC separation will be reduced. The TSG should never be operated on the air with program material when the clippers are jumped OUT.

These jumpers are on the “D2” card, which is piggy-backed on the “D” card. They are located about one inch back and slightly toward the center of the card from the L+R CLIP and L-R CLIP trim pots.

Mode	PS201 Jumper	PS301 Jumper
Clippers In	1 to 2 *	1 to 2 *
Clippers Out	2 to 3	2 to 3

3.17.8 Pilot Phase Control In Or Out (“G” Card)

The digital subcarrier modulator and digital pilot generator used in the TSG produce correct pilot phase without trimming. A pilot phase control is provided to compensate for non-ideal phase response in other parts of the transmission system. The pilot phase control may be strapped out if it is not needed.

Mode	PS1 Strap
Pilot Phase Control In	2 to 3 *
Pilot Phase Control Out	Removed

3.17.9 Power-Up Mode (“C” Card)

The TSG may be set to go into either MONO or STEREO mode when power is applied. Consider which mode is desirable after a brief power failure.

Mode	PS1 Jumper
Stereo	1 to 2 *
Mono	2 to 3

Chapter 4

Operating Procedures

4.1 Front Panel Controls

4.1.1 Meter Selector Right(>)

This control moves the selected meter channel to the right. It is duplicated exactly by the remote control.

4.1.2 Meter Selector Left (<)

This control moves the selected meter channel to the left. Note that this control is not duplicated on the remote control interface. The corresponding remote control function forces the meter selector to Position 1 (TOTAL).

4.1.3 Loudness Step

Each time this button is pressed, an additional 0.5 dB of attenuation is added after the processor. This control is intended to allow for reducing the loudness of offensive commercials. It is duplicated by the remote control.

4.1.4 Loudness Reset

Pressing this button will gradually remove any attenuation added by operating the STEP control. It is a ramp function that restores the gain slowly over several seconds so as not to be noticeable. This control is duplicated by the remote control.

4.1.5 Mono/Stereo

Selects stereo or mono mode of operation on an alternate action basis. Its function is duplicated by two controls (Stereo ON, Stereo OFF) on the remote control.

4.2 Front Panel Indicators

4.2.1 Attenuation

Two digits of LED 7 segment displays indicate in dB the amount of loudness control taking place. The valid indications are 0 dB to -9.5 dB.

4.2.2 Stereo

An indication that the TSG is in the stereo mode.

4.2.3 Mono

An indication that the TSG is in the monaural mode. It may be in mono mode either because that mode was selected or because of loss of composite video (sync).

4.2.4 Sync

Indicates the presence of the horizontal sync signal needed to lock the stereo to exactly sync rate. Loss of sync lock will cause the TSG to immediately revert to monaural operation.

4.2.5 Stereo Rev

If either of the Left or Right audio channels is polarity reversed, creating what is popularly called an “out of phase” condition, this red LED will come on immediately and the STEREO REVERSE alarm contacts on the back panel will close.

Additionally, if a condition of mono incompatibility exists, the alarm will come on. This need not be the result of a polarity reversal, but could be caused by poor placement of microphones in a stereo pickup or the overzealous application of a stereo synthesizer.

Such a condition should be corrected at once because it indicates that monaural listeners (using conventional non-stereo sets) are receiving a degraded signal.

The alarm threshold is factory set at -0.85 on the L/R CORR meter scale. If the alarm frequently trips and you have determined that there is no fault with the program material, you may want to adjust the alarm threshold—see Chapter 3, Section 4.5.

4.3 Meter Functions And Readings

This section of the manual explains the modulation parameters and correct meter readings for each of the TSG’s operating modes. Meter functions are numbered 1 to 15 in the following table. The explanations follow (from left to right) the order of the modulation and audio indicators as they appear on the front panel. Section 4.4 of this chapter is a table which shows the correct meter reading for each mode.

Note that the meter ballistics are fast attack, peak hold, and slow release for all meter functions except GR, HFR, and PLL. These three positions measure control voltages and the peak hold circuit is not used. The attack characteristic in the AUDIO positions is similar to that of a PPM (peak program meter). In the MODULATION positions, a faster attack characteristic is used to allow accurate measurement of modulation peaks. All AUDIO parameters are read with pre-emphasis.

4.3.1 Modulation Parameters

4.3.1.1. Total

The deviation of the entire baseband including all components: L+R, pilot, L-R, SAP and PRO. It is read on the top scale (0-120) with 100 corresponding to 73 kHz deviation.

If operation is in stereo only, the maximum deviation is 55 kHz or 75.3 on the meter. To determine the maximum deviation for any combination of subcarriers, use the table in Section 4.5 of this manual.

Note that when in normal stereo mode with no input signal applied the TOTAL meter may indicate up to 15 kHz of deviation (20 on the meter scale). This is a normal condition caused by the 5 kHz deviation of the pilot and the noise of BTSC encoder. See the detailed explanation of this noise in the discussion of the L-R modulation function (position 3).

4.3.1.2. L+R

The deviation of the baseband caused by the sum of the Left and Right components in the range from 20 Hz to 15 kHz. It also indicates total deviation when the TSG is in mono mode. Readings are on the top scale with 100 corresponding to 25 kHz deviation.

4.3.1.3. L-R

The deviation of the baseband caused by the L-R double sideband suppressed carrier subcarrier. This subcarrier is centered at twice the horizontal sync rate (31.468 kHz). It is modulated by the BTSC encoded Left minus Right "difference" signal. Because of the nature of the BTSC noise reduction process, the encoded L-R signal produces a great deal of noise under no-signal conditions. The result is that in normal stereo operation with no audio applied to the stereo generator, a residual noise deviation of 5 to 10 kHz will be present. This is a normal condition for the BTSC encode/decode noise reduction system and does not represent a malfunction.

L-R modulation is read on the top scale and 100 corresponds to 50 kHz deviation.

4.3.1.4. PILOT

The deviation of the baseband caused by the unmodulated pilot reference tone. This pilot is locked to the video horizontal sync at 15,734 Hz. Its specified deviation of ± 5 kHz corresponds to 100 on the top scale.

4.3.1.5. SAP

The deviation of the baseband by the Second Audio Program subcarrier (SAP). The SAP is a BTSC noise reduction encoded FM subcarrier at a frequency of five times the horizontal sync rate (78.67 kHz). It is generated by an external unit such as the Modulation Sciences TV SIDEKICK and fed into the TSG for summing into the composite baseband.

Its specified deviation of the main carrier (injection) is ± 15 kHz, corresponding to 100 on the top scale.

Note that this is an unvarying parameter—the deviation of the main aural carrier by the SAP subcarrier. It is **not** the deviation of the subcarrier by the SAP program material. The deviation of the subcarrier is a varying signal measured by the SAP generator, **not** by the TSG.

4.3.1.6. PRO

The deviation of the main aural carrier by the professional channel.

The PRO channel is an FM subcarrier at a frequency of 6.5 times the horizontal sync rate (102.271 kHz). It is generated by an external unit such as the Modulation Sciences PRO SIDEKICK and is fed into the TSG for summing into the composite baseband.

Note that this is an unvarying parameter — the deviation of the main aural carrier by the PRO subcarrier. A reading of 100 on the top scale means ± 3 kHz deviation of the main carrier (injection). It is **not** the deviation of the subcarrier by the PRO program material. That deviation is a varying signal that is measured by the PRO generator, **not** the TSG.

4.3.2 Audio Parameters

4.3.2.1. *GR*

The total gain status of the audio processor is indicated by the GR or gain reduction position. It is read on the bottom scale (+1, 0, -1). A reading will be obtained in this position only if the audio processor option is installed.

This is the most important parameter for day-to-day operation of the TSG and for the initial setup of the audio processor.

The zero or center scale position is the no-signal gain of the system. As the pointer moves to the right (toward -1), an increase in gain is taking place. Motion to the left of center (toward +1) means gain reduction is taking place. Under normal program conditions, the meter should swing halfway between center scale and full left deflection. The farther toward +1 the meter is, the more processing is taking place. For a more detailed explanation of this position, see Section 4.7 of this chapter on setting up the audio processor.

4.3.2.2. *HFR*

High-frequency gain reduction is monitored by HFR. It is read on the middle scale (-20 dB to +2 dB). The normal resting place is 0 dB on the scale and high-frequency gain reduction will drive the meter to the left (toward -20 dB). (A reading will be obtained in this position only if the audio processor option is installed.)

HFR is used to set up the HFR control on the audio processor and is fully explained in Section 4.8.4 of this manual.

Note that the action of this reading depends almost entirely on the high-frequency content of the program material. Films dubbed from optical tracks often have little energy above 8 kHz and thus will show no action on the HFR position. Live music will tend to show the greatest action.

4.3.2.3 *L*

The Left channel position is read on the middle scale (-20 dB to +2 dB) of the meter. It indicates the level following the audio processor and is pre-emphasized. Balance can be set approximately by using the L and R indication. It is also useful for a quick check to see if audio is reaching the TSG.

4.3.2.4 R

The Right channel companion to the Left channel discussed above.

4.3.2.5 L+R

Left plus Right audio is the sum output of the matrix following pre-emphasis.

4.3.2.6 L-R

Left minus Right audio is the difference output of the matrix following pre-emphasis.

It is most useful for setting the balance between the Left and Right channels. The procedure is to send the same program material to both the Left and Right STL channels. This can be done either by using a monaural program source or by connecting the same source to both the Left and Right inputs on the console. Often, consoles have a "mono" switch on them. Channel balance should be "roughed in" by using the L and R meter positions, then set for a null in the L-R position.

4.3.2.7 L-R +20 dB

This position is identical to the above except that an additional 20 dB of gain is added. This permits final tweaking of channel balance for the best balance (deepest null).

4.3.2.8 L/R CORR

Left/Right correlation is a function unique to the TSG. It functions as what is popularly known as a phase meter. This position provides an indication of the degree of monaural compatibility of the program material.

It is all too easy to have a situation in which the stereo audio sounds great but the mono is awful. With the majority of viewers still using monaural receivers, poor mono performance could have a widespread adverse impact. Although there is no substitute for listening to the monaural signal, the correlation meter position gives an excellent gross indication of any problems. A steady reading of +1 means the program material is monaural. A reading varying between +1.0 and about +0.4 is typical for mono-compatible stereo program material. Readings between +1.0 to 0 are typical for many modern popular music recordings that are created without an overriding concern for mono compatibility. Any reading that is significantly negative means serious problems for the mono audience.

The correlation function is especially useful for setting up a stereo synthesizer. The controls on the synthesizer should be adjusted for a correlation reading between +0.7 and +0.3. Of course, any such adjustments should be supplemented by careful listening to both the monaural and the stereo sound, but the correlation meter provides an objective indication.

4.3.2.9 PLL

The loop control voltage for the phase locking of the sync extractor circuit. This is a troubleshooting function that provides a check on the status of the critical circuit that strips horizontal sync from composite video.

4.4 Meter Calibration Table

This table lists the meter position functions. For each of the MODULATION positions, the deviation of the aural carrier for a meter reading of 100 is provided.

The AUDIO positions provide the input level of the matrix for Left and Right, while the L+R and L-R indications are for the output of the matrix.

The values given in the table correspond to an indication of 100 on the top scale of the meter or 0 on the middle (VU) scale.

Meter Position	100% Indication
Modulation:	(Top Scale)
Total	?73 kHz deviation
L+R	?25 kHz deviation
L-R	?50 kHz deviation
Pilot	?5 kHz deviation
SAP	?15 kHz deviation
PRO	?3 kHz deviation
Audio:	
L Only	100% produces 50% L+R and 50% L-R
R Only	100% produces 50% L+R and 50% L-R
L+R	100% modulation
L-R	100% modulation
L-R +20dB	10% modulation

Note: In TOTAL MODULATION MODE with only Stereo and Pilot, the peak deviation is limited to ?55 kHz. This corresponds to a reading of 75.3 on the top scale of the meter.

Meter Position	Meter Reading
	(Bottom Scale)
Audio: L/R CORR	+1 = L and R identical and in phase
	0 = L and R totally uncorrelated
	-1 = L and R identical but out of phase

4.5 Total Modulation Deviation Table

The following table allows the calculation of peak deviation limits for all possible combinations of MTS signals. To find the correct TOTAL MODULATION reading, add the reading values for each modulating component from the last column of the table below. Note that because of interleaving, the ?25 kHz monaural deviation is not added into the total deviation once stereo is in use.

Signal	Deviation (kHz)	% Reading of Total Mod
Monaural	?25	34.2*
Stereo (L+R, L-R, & Pilot)	?55	75.3
SAP	?15	20.5
PRO	?3	4.1

*The monaural deviation is included in the stereo deviation. Therefore, when stereo is used, the mono deviation is not added in to calculate a total deviation or meter reading.

4.6 RF Shield Panel Controls and Indicators

4.6.1 Left Input Level

A multi-turn trimpot that adjusts the audio input level to the TSG.

4.6.2 Right Input Level

The same as LEFT INPUT LEVEL.

4.6.3 Gate Indicator

When lit, this LED indicates that the program level is above threshold and normal automatic level control is taking place. When off, level control action is frozen to prevent noise swishing normally associated with automatic gain control.

During normal dramatic dialogue without a music background, the LED should flash a great deal, indicating that gating is taking place during the frequent short pauses in speech.

4.6.4 Flat / 75 ? sec Switch

Switches the pre-emphasis in and out. Useful for frequency response and channel separation testing. The FLAT position is needed in precise setup to reduce the effect of noise on the level setting.

4.6.5 Norm / Bypass (“A” Card)

In BYPASS, this disables the function of the audio processor entirely. It is necessary to disable the audio processor for most measurements.

4.6.6 Gate Control

Sets the threshold below the point at which the audio processor freezes (gates) the gain of the AGC. Clockwise rotation increases the level at which gating takes place. Gating is indicated by the amber GATE LED being off.

4.6.7 HFR

Controls the action of the high-frequency limiter in the audio processor. In the clockwise position, high-frequency response is reduced as much as necessary to hold peaks to 100% modulation. In the counterclockwise position, high-frequency limiting is effectively defeated and the peaks will be controlled by the clippers on the “D” card.

4.6.8 LIMIT

When fully counterclockwise, this protects the clippers through AGC action. When fully clockwise, there is 2 to 3 dB of clipping. Generally, clipping (clockwise) sounds “brighter” than AGC (counterclockwise); however, if the audio has been heavily processed before reaching the TSG, clipping will make it sound distorted.

4.6.9 REF LEVEL

These two LEDs indicate when the BTSC encoder is at the ± 25 kHz deviation reference point. This level must be precisely known in order to set the modulation sensitivity of the aural exciter and to align a decoder. When the green light is on and the red off, the level is correct to ± 0.03 dB. If this condition cannot be achieved either because both LEDs come on at the same time or one or the other flashes, the test tone is either noisy or has hum on it. See Chapter 3, Section 3.11.8.

4.6.10 Norm / Bypass (“D” Card)

In the NORM position, this switch selects BTSC encoding. In BYPASS, the TSG is in Equivalent mode. Most testing is done in the 75 μ sec Equivalent mode. The paper “Understanding Equivalent Mode” discusses this fully. A copy of it may be found inside the front cover of this manual.

4.6.11 Pilot Phase

This controls the zero crossing point of the 15,734 Hz pilot relative to the 31,468 Hz L-R double sideband suppressed subcarrier component. It is an optional control, provided to permit compensation for errors in the aural transmitter. A strap option on the “G” card allows selection of coincident zero crossing (no phase correction) or enabling of the pilot trim adjustment.

Detailed setup instructions for this control are provided in Appendix C.

4.6.12 Comp Level

This control sets the composite output level of the entire TSG. Its setting is critical to the system performance of the TSG. Adjustment of the composite level should only be made under Bessel null test conditions as described in Chapter 3, Section 3.12 or 3.13. A modulation monitor is not accurate enough to permit adjustment of composite level.

4.6.13 L-R LEVEL

This control adjusts the modulation level of the L-R subcarrier. It is a critical adjustment that has a major impact on stereo separation. L-R level adjustment is the main compensation that may be applied when the aural exciter/transmitter has less than ideal amplitude response. Full details on this adjustment may be found in Appendix C.

4.6.14 Pilot Level

Adjusts the deviation of the main carrier by the 15,734 Hz pilot tone (pilot injection). This non-critical adjustment is made by using the PILOT MODULATION position of the internal meter. A reading of 100 on the top scale corresponds to the required 75 kHz deviation.

4.6.15 L-R Level Test / Norm

When in the TEST position, this switch defeats the +6.02 dB offset applied to L-R subcarrier modulation as mandated by BTSC standards. This offset provides the best possible noise performance for BTSC companded signals and is part of the BTSC standard. However, it makes many conventional stereo tests impossible. The L-R LEVEL switch defeats this offset to enable testing. Appendix C describes the tests that need this switch.

4.6.16 Pilot Off / On

This switch removes the 15,734 Hz pilot without affecting the rest of the stereo composite baseband. The pilot must be switched off to make oscilloscope separation measurements as described in Appendix C.

4.6.17 L+R Off / On

This switch removes the L+R modulation from the composite baseband. It is used in measuring pilot phase as described in Appendix C.

4.6.18 L-R TEST / NORM

When in the TEST position, this switch selects the L+R signal to modulate the L-R subcarrier instead of the L-R (difference) signal. This test mode makes it simple to generate a Left or Right equivalent mode signal with any modulation needed. The matrix and noise reduction systems are bypassed, so extremely accurate separation measurements can be made. This switch is also used to set pilot phase with an oscilloscope as described in Appendix C.

4.6.19 R Only / L Only

This switch is active only when the L-R SIGNAL switch located above it is in the TEST position. When active, it selects either left or right channel modulation.

4.6.20 SYNC

This LED indicates the presence of horizontal sync as derived from composite video. The TSG will drop out of the stereo mode unless sync is present.

4.6.21 L-R CLIP

This control sets the operating point of an audio clipper located in the L-R channel after BTSC encoding. Its purpose is to control very brief peaks of overmodulation that result from the BTSC encoding process and to control filter overshoot. It is factory set to 90% of full L-R modulation, allowing 10% for overshoot in the portion of the filter following the clipper.

The L-R CLIP and L+R CLIP controls vary the “hardness” of the TSG’s modulation control. The clipping level can be adjusted from about 70% to 100% continuous (sine wave) modulation.

The CLIP controls allow varying the degree of absolute modulation control to satisfy differing interpretations of what is acceptable modulation control. The factory setting of these controls represents Modulation Sciences’ best judgment of an acceptable compromise.

4.6.22 L+R CLIP

This control is identical to L-R CLIP except that it operates on the L+R (sum) signal.

4.7 What The Audio Processor Does

4.7.1 The audio processor “rides gain” to maintain reasonable modulation levels. A variety of techniques is used to make these gain changes as inaudible to the listener as possible. (For a detailed description of these techniques, see Section 9.0 of this chapter.) The short-term dynamics of the audio are changed as little as possible because most listeners are quite sensitive to such changes.

The processor operates as either a compressor or expander, depending on the input program level. It can compress by 10 dB and expand by 10 dB for a total gain control range of 20 dB. The GR (gain reduction) meter position shows the amount of gain change. On the bottom meter scale, 0 is the unity gain point, that is, the point at which the processor is neither compressing nor expanding. A meter reading of +1 on this scale corresponds to 10 dB of compression and -1 corresponds to 10 dB of expansion.

4.7.2 The processor prevents overmodulation of high-frequency program components which have been boosted by the 75 μ sec pre-emphasis on the L+R channel. Pre-emphasis (and later de-emphasis in the receiver) is an attempt to improve the signal-to-noise ratio. It succeeds only because much program material has high-frequency energy which approximately declines with frequency according to the inverse of the pre-emphasis curve. Thus, after pre-emphasis, the peak level of the signal is not significantly increased. For material which has a great deal of high-frequency energy, some corrective action must be taken to prevent distortion or overmodulation by this additional energy. The simplest thing to do would be to reduce the overall signal level to hold the high-frequency peaks below 100% modulation. Unfortunately, a long-term level reduction sufficient to hold peaks to 100% compromises signal-to-noise ratio, improvement of which was the reason for using pre-emphasis in the first place. Momentary broadband level reductions to accommodate the peaks sound quite unnatural, since the human ear pays more attention to midrange than to high frequencies. To avoid these effects, the audio processor uses adaptive pre-emphasis. When excessive high-frequency peaks are detected, pre-emphasis is momentarily reduced to control the peak level. Thus, unnatural broadband level reduction is avoided.

Two additional mechanisms are provided to control peaks — limiting and clipping. Limiting is gain reduction with a very fast attack time and a relatively fast release time. It can reduce the level of a single transient without greatly affecting the bulk of the program material. Since gain is actually reduced for the duration of the transient, little distortion is produced. However, the level of the single transient is audibly reduced.

Clipping sets a threshold which peaks are not allowed to exceed, even instantaneously. Once the signal waveform has reached the threshold, the output is clamped to this level. Portions of the waveform below the threshold are unaffected. Clipping a continuous signal (extreme example: a sine wave) produces audible distortion, but clipping brief transients produces relatively little audible distortion. When used in moderation, clipping can control peaks effectively without audibly reducing transient levels. However, the line between moderation and excess is very thin and excessive clipping can sound quite offensive.

4.7.3 The audio processor coordinates all of these activities to provide maximum effect. To avoid excessive clipping, a special circuit monitors the degree of clipping and substitutes limiting or gain reduction for clipping when necessary. A single control (HFR) allows the user to set the balance between adaptive pre-emphasis and limiting/clipping. Peaks which are not controlled by adaptive pre-emphasis will automatically be dealt with by limiting or clipping. Other circuitry monitors the frequency and duration of transient limiting and sets the balance between limiting and gain reduction.

4.7.4 In addition to the functions outlined above, the audio processor compensates for a distortion-generating side effect of the BTSC noise reduction system. The L+R channel deviates the aural carrier a maximum of ± 25 kHz, the L-R channel deviates a maximum of ± 50 kHz, and the pilot signal deviates a constant ± 5 kHz. The entire stereo signal must not deviate the aural carrier more than ± 55 kHz. If you think there's some kind of new math going on here, you're right. The trick is that over much of the audio frequency range, the noise reduction system in the L-R channel has a phase shift of about 90° . Since the signal peaks in the L+R and L-R channels do not occur at the same time, the peak level of the composite signal is significantly less than the sum of its components. This distortion-generating side effect occurs at high frequencies, where the phase shift is more nearly zero and the peak levels **do** add directly. To combat this effect, the audio processor monitors the composite level and reduces gain when necessary to prevent overmodulation.

4.8 Adjustment Of Audio Processor Controls

Some audio processor adjustments are objective: Levels can be set by using tones; trim pots can be set to specific rotations according to instructions. Other adjustments are subjective: You will have to listen to your broadcast signal and decide whether you like what you hear and what to do about it if you don't. The key word here is **listen**. If you don't have a reasonably quiet location where you can listen to your signal in both stereo and mono, making subjective adjustments will be difficult. Typical control settings are given below for "subjective adjustment" controls.

4.8.1 Initial Control Settings

GATE	12 o'clock
HFR	6 o'clock
LIMIT	12 o'clock

These settings are as you view the card mounted in the card cage. Note that the extreme rotations of the controls are at about 10 o'clock and 8 o'clock in this view.

4.8.2 Definition Of Terms

4.8.2.1 Peak Program Level

Peak Program Level is measured by using a Peak Program Meter (PPM). The characteristics of this meter are defined by a British standard. The attack time is carefully controlled so that it responds to peaks humans can hear while ignoring extremely brief transients. In the AUDIO positions, the TSG meter has attack characteristics similar to a PPM, although its release time is longer than that of a PPM. In this discussion, 0 dB PPM = 0 dBm for a steady sine wave.

4.8.2.2 Program Level

Program Level is measured by using a VU meter. For this discussion, 0 VU = 0 dBm for a steady sine wave. The Peak Program Level of a signal set to 0 VU depends on the nature of the signal. For sine waves, the readings are identical. For program material, PPM readings are typically 6 to 10 dB higher than VU meter readings. We assume the difference to be 8 dB.

4.8.2.3 Nominal Peak Program Level

The Peak Program level, measured at the TSG inputs, will produce a GR meter reading of 0 (center scale). This depends principally upon the settings of the TSG INPUT LEVEL controls.

4.8.2.4 Operating Peak Program Level

The highest Peak Program Level which should occur in normal program material if everything were operating perfectly. (In other words, the point where the operator should set the program level.) If you use VU levels, add 8 dB to get Operating Peak Program Level.

4.8.2.5 Background Noise

Background noise is any signal which is not a primary part of the program material. It may be a deliberate part of the program material; for example, street noise in an outdoor scene or whispering leaves in a forest scene. It may also be undesired noise such as hiss from an optical sound track. In any case, the audio processor should not make “gain riding” decisions based on background noise.

4.8.3 Setting Input Levels And Gate Control

4.8.3.1 First, let's define the allowable range of input levels. The input amplifiers clip at +20 dBm, so this is clearly the maximum Peak Program Level which should be used. If we assume that this input level produces maximum (10 dB) compression, then the Nominal Peak Program Level (that is, the level which will produce a GR meter reading of 0) cannot exceed +10 dBm.

With the INPUT LEVEL controls set maximum CW, a Peak Program Level of -7 dBm will produce a GR meter reading of about zero. Thus, the possible range of Nominal Peak Program Levels is from -7 to +10 dBm. This corresponds approximately to VU levels of -15 to +2. If you don't need to use the entire 10 dB compression range of the audio processor, Nominal Peak Program Levels can exceed +10 dBm.

4.8.3.2 The simplest setup of the audio processor is to set the Nominal and Operating Peak Program Levels to be equal. This is the setup given in the installation instructions. With this setup, compression will be used to correct levels which are too high and expansion will be used to correct levels which are too low. GR meter readings should average somewhere near zero with normal program material.

4.8.3.3. Before discussing alternative level settings, let's take a look at the effect of the GATE circuit on the processor's compression and expansion characteristics. The GATE circuit compares the audio processor's left and right input signals to a threshold set by the GATE control. The threshold can be set from 15 to 30 dB below Nominal Peak Program Level. When either input signal is above the GATE threshold, the GATE LED is lit and the audio processor operates normally. When both signals are below the threshold, the GATE LED is off and the broadband gain is "frozen". If the signals remain below the threshold for more than about 5 seconds, the gain will slowly return to unity ($GR = 0$) with complete recovery taking about 30 seconds.

4.8.3.4 The GATE circuit is fast enough to operate in pauses between words and phrases in speech or in momentary pauses in music. As long as background noise remains below the GATE threshold, it will not "rush up" (breathe) to fill the pauses. In effect, the processor's gain-setting decisions are based only on the portion of the signal above the threshold. If you want to use the complete gain control range of the processor, the GATE threshold should be set as low as possible. You should check a variety of program material to see that background noise generally remains below the threshold you have set.

It is also possible to set the threshold considerably above background noise. GATE control settings between 3 o'clock and 8 o'clock will affect the processor's expansion characteristics. As the signal level drops, more of the primary portions of the program material will be below the gate threshold. This effectively lengthens the expansion time constants as expansion increases.

At the extreme CW setting of the GATE control, the processor will rarely reach maximum expansion. This setting may be useful if you don't want to use the complete expansion range. Ordinarily, the primary portions of the program material should stay above the GATE threshold. If your program material has extremely wide dynamic range, this may not be possible, even with the GATE control set fully CCW. In this case, it is best to set the GATE control fully CW to prevent full expansion. When program material is below the GATE threshold for extended periods of time, the return to unity gain from full expansion produces a "drop-out" effect.

4.8.3.5. The compression characteristics are not changed very much by the GATE control. Any signal which can cause compression is at least 15 dB above the GATE threshold, so most of the primary portions of the program material remain above the threshold.

4.8.3.6 Now, back to level settings. Unless you are broadcasting material having extremely wide dynamic range, best results will be obtained if the primary parts of the program material stay within the control range of the processor. The upper limit of this range is 10 dB of compression ($GR = +1$). If GR ever goes beyond +1, input levels should be reduced. The lower limit of the control range is the point where the signal is so frequently below the GATE threshold that expansion stops and gain starts to return to unity.

4.8.3.7 To determine whether you need to adjust input levels, you should observe the GR readings for a variety of program material. If GR frequently goes to -1 and rarely goes above 0, input levels should be increased. If the GATE LED frequently stays off for more than 10 seconds when program material is not background noise, either the GATE threshold should be lowered or input levels should be increased. If GR readings are usually between 0 and +1 and rarely, if ever, reach -1, input levels should probably be reduced.

Best results are usually obtained when the long-term average of the GR reading is about zero, or, if the limits given above are not exceeded, this average tends slightly toward expansion. If the average is predominantly in the compression region, input levels should be reduced unless doing so causes the limits given above to be exceeded.

4.8.4 Adjusting The HFR and Limit Controls

4.8.4.1 The 75 μ sec pre-emphasis curve has its knee (+3 dB point) at 2.1 kHz and rises at 6 dB/octave. It boosts 15 kHz by 17 dB. The HFR control sets a threshold ranging from 0 to 6 dB above the broadband gain control threshold. When the peak level of the pre-emphasized signal exceeds the HFR threshold, the boost produced by the pre-emphasis curve is momentarily reduced to hold peaks to the threshold level.

If the program material contains enough high-frequency energy, pre-emphasis has to be entirely defeated to control the peak level. Fortunately, this condition, which is reached only when the program material is a high-frequency sine wave, occurs quite rarely. Most of the time, only a part of the pre-emphasis needs to be defeated. Since the human ear is considerably more sensitive to 2 kHz than to 15 kHz, the TSG audio processor starts its reduction at 15 kHz and moves downward as necessary. For most program material, this produces maximum peak reduction with minimum audible effect.

4.8.4.2 When the HFR control is set fully CW, the HFR threshold and the broadband threshold are identical. With this setting, the peak level of the pre-emphasized signal will be no higher than that of the flat signal. The maximum amount of high-frequency reduction will be used and the loss of high frequencies may become audible. Fortunately, this extreme setting is rarely necessary.

As the HFR control is rotated CCW, the peak level of the pre-emphasized signal will exceed that of the flat signal up to a maximum of 6 dB at the extreme CCW rotation of the control. These peaks will be controlled by the clippers located on the "D" card. The amount of clipping for any HFR setting is determined by the setting of the LIMIT control on the "A" card and by the settings of the L+R and L-R CLIP controls on the "D" card.

4.8.4.3 Using less HFR and more clipping will result in a "brighter" sound, but using too much clipping will result in audible distortion. This distortion is particularly obvious on sibilants in speech. In music, it will cause instruments such as cymbals or horns to sound "splasy" or harsh. To find the correct adjustment of the HFR control, turn it CCW until you start to hear distortion, then turn it slightly CW until the distortion disappears.

It should be noted here that not all program material contains enough high-frequency energy to cause high-frequency reduction, even with the HFR control set fully CW. To arrive at a proper adjustment, you must use program material with enough high-frequency energy to produce high-frequency reduction. If the audio has been through another processor before the TSG (for example, a limiter to protect your STL), the high frequencies may already have been reduced. If you don't see much high-frequency reduction on normal program material, it may be necessary to find a piece of music with lots of high frequencies and make this adjustment during maintenance hours. Alternatively, you can adjust the HFR control a fraction of a turn each day and monitor your air signal to see if you've gone too far. In any case, if you don't see at least occasional high-frequency reduction, it is unwise to leave the HFR control set further CCW than 5 o'clock.

4.8.4.4 The LIMIT control varies both the broadband and HFR thresholds over a 3 dB range. These thresholds are lowest at the extreme CCW setting. This produces lower average modulation and less clipping, since the clipping threshold is set to a fixed modulation percentage. The LIMIT and HFR controls interact — with the LIMIT control set to minimum (fully CCW), less HFR (control further CCW) will be needed to prevent audible distortion. As the LIMIT control is set further CW, the average modulation level will increase, more clipping will occur, and more HFR (control further CW) will likely be required.

4.8.4.5 The broadcast signal is obviously most faithful to the original with the LIMIT control fully CCW. At the recommended setting of 12 o'clock, the processing thresholds are about 1 dB above the minimum levels and only a modest additional amount of HFR and clipping will be needed to control modulation levels. To arrive at a setting for the LIMIT control, you must decide whether you need to increase the average modulation level, and, if so, whether you can hear the additional processing required.

Unlike FM stereo, the switch to stereo in television does not reduce coverage area because of signal-to-noise problems. The BTSC noise reduction system in the L-R channel gives stereo listeners just as quiet a signal as what mono listeners receive. In fringe areas, picture noise and not audio noise generally limits coverage. The TSG audio processor has been designed to solve stereo TV's unique technical problems while maintaining L+R modulation comparable to previous monaural levels. It is not designed as a "squasher-squeezer" to increase modulation levels. Stereo television is producing more sophisticated receivers (and listeners) and will require a commensurate increase in audio quality.

4.9 Audio Processor: Theory Of Operation

Figure 4-1, located at the end of this chapter, is a block diagram you may find useful in following this discussion of the way the TSG's audio processor operates.

4.9.1 Broadband Long Term Level Control

4.9.1.1 Before entering the "A" Card processor module, the audio signal has already been partially low-pass filtered in order to prevent unintended responses to out-of-band spurious signals. The input buffer (U1 and associated items) differentially receives the signal from the input module and passes it to the gate detectors and VCAs (voltage-controlled amplifiers). The level controller is a servo circuit so the various level detectors operate from the output of the VCAs (U2, U3 and related components).

4.9.1.2 The limit reference voltage (to be discussed later) is presented to Detectors 1 & 2 (U17, U19, U20, Q1, Q2, etc.). The reference on Detector 2 is lower than the reference on Detector 1. As a result, a signal increasing in level will be detected first by Detector 2, then by Detector 1. Detector 2 is not of interest until the input level begins to decrease. The output of Detector 1 is scaled in the summation and scaling circuit (U34, U28, etc.) and applied to the VCAs. This operation has a fairly slow attack time constant and establishes the basic compression of the signal. Once this has happened, and assuming the incoming level begins at some point to decrease, the control voltage must be permitted to recover and restore the gain to the nominal value.

4.9.1.3 The manner of this recovery is one of the primary determining aspects of how the controller will sound. In most processors, the recovery characteristic is described only in terms of time and it is assumed that the amplitude behavior is simply inverse to the input. In this processor, the relationship is more complex and more nearly optimum. There are several recovery mechanisms at work.

The main recovery mechanism is dependent on both amplitude and time. When the input signal begins to decrease, there is initially no recovery. Once the input has decreased below the threshold of Detector 2, the recovery is governed by the recent history of the program material. This is accomplished by the use of multiple storage circuits (U33, U35, Q4, Q5, and related components).

The result of this approach is that the short term dynamics of the program are generally preserved and the movement of the controller from one “zone” of gain to another does not draw attention to itself. An additional slow recovery is allowed within a given gain zone to produce subjectively natural results when processing certain types of material, especially speech.

4.9.2 Peak Level Control

4.9.2.1 The limit reference voltage is applied to Detector 3 (U26, etc.). This detector is dissimilar to Detector 1 but shares exactly the same reference voltage. The attack time is quite fast so that the envelope of most normal sounds will be followed accurately. The result is that Detector 3 handles the leading edge of most transient level increases. The recovery connected with this detector is also quite fast and is closely matched to the attack characteristic of Detector 1. By itself, this fast recovery would sound quite unacceptable on most material, but in this “nested” arrangement with the long-term controller, the recovery of the limit loop is not heard. The result of this topology is significantly superior in practice to what can be accomplished with a “compressor” and “limiter” in cascade.

4.9.2.2 All level detection is done on a “higher of the two channels” basis and the control signals are applied identically to the VCAs. The tracking of the gain control elements is carefully trimmed and is essentially identical within the whole range of interest. Thus, the identity of the stereo channels is maintained.

4.9.3 Gating

It is essential in a wide range controller such as this that sudden lapses in the input do not cause large amounts of sudden gain recovery (pumping). Detector 4 (U15, U16, U18, etc.) is sensitive to the input level. When it drops below a threshold set by the “gate” control (RV11), all recovery mechanisms are inhibited. The gate time constants are fast enough that the silence between the syllables of speech will be detected and will have the effect of lengthening the single time constant slow recovery (which is not affected by the amplitude hysteresis). The range of gate threshold adjustment extends from -15 dB to -30 dB with respect to the nominal input level. An indicator LED is provided to assist in setting up the gate.

4.9.4 High-Frequency Limiting

This process, when systematically applied to a system with fixed pre-emphasis, is also known as adaptive pre-emphasis.

4.9.4.1 The 75 μ sec pre-emphasis is applied to the signal (C5, C14, R14, R39, R15, R40). An identical inverted signal path with gain control (U5, U6, U7, U9, C6, C15, R17, R42) allows partial or complete cancellation of the pre-emphasis. Compared to others, this method has the important advantage that, as the pre-emphasis is reduced, the slope of attenuation changes but the frequency of inflection does not change. This is very important because the receiver de-emphasis is fixed and variations in the inflection frequency will cause significant errors in the region from 2 to 5 kHz which are particularly audible.

4.9.4.2 The adaptive pre-emphasis circuit is operated by Detector 5 and its recovery network (U8, U10, U29, U31, etc.). The threshold for this detector is set from 0.1 to 6 dB above the limit threshold. The distance is user-adjustable via the HFR control. Setting the threshold near the limit level will result in the maximum amount of high-frequency control (CW setting). Moving it above the limit level (CCW) will result in less high-frequency control and it will cause more clipping in the filters of the BTSC encoder section. This is permissible, as these clippers exist for the purpose of instantaneous modulation control and are a specified part of the system.

4.9.4.3 The use of less HFL and more clipping is said to result in a “harder” sound, while the use of more HFL and less clipping is said to produce a “softer” sound. In fact, because this high-frequency processor is free of the commonly encountered response error (described above), it is possible to use a great amount of pre-emphasis control and it will be hardly noticeable. While this is in the realm of subjective preference, it can be argued that the avoidance of clipping will result in lower distortion and less listening fatigue.

4.9.4.4 A special note: Many high-frequency processors do not couple the control elements. While an accurately tracking pair of control elements is difficult to implement, the need is absolute and incontestable. Designers who fail to do this will disclaim the need for it, but this is contrary to even the most rudimentary understanding of the requirements for stereo. The STVA processor circuits perform **identically** in the two channels, thus accurately preserving the stereo image.

4.9.5 Threshold Generation

The master threshold generator is U29. The basic limit level (hence all other references except the gate) is user adjustable through a range of about 3 dB via "limit" control RV10. The CW setting of RV10 results in the highest threshold, hence the highest output level (modulation). This master voltage is further subject to automatic adjustment by Detectors 6 and 7 and their associated circuits (U12, U13, U14, U23, U32). The purpose of these is to control the modulation in the presence of program material which is statistically less than optimum with respect to BTSC encoding and stereo generation.

4.9.6 Matrixing

The processed audio signal leaves the module as sum and difference for BTSC encoding. U11 and associated components form a precision matrix for this purpose.

4.9.7 Metering

The audio processor is part of a mainframe system where the metering facilities are located. Various signals (L, R, L+R, L-R, HFR, GR) are sent to the mainframe via a multiplexer which is digitally controlled from the mainframe meter function selector. Because the high-frequency limiter acts very fast, the metering output is peak detected and stretched for easy observation. The GR metering function tends to show the broadband long term control status because the fast limit loop operates too quickly to view. This is not a liability because of the fixed relationship between the detectors.

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Chapter 5

Routine Maintenance

5.1 Introduction

The TSG needs no regular maintenance. The TSG's inherent stability over time and temperature far exceeds that of most aural exciters. It is, however, useful to verify the performance of the systems that surround it — the audio chain providing its input and the aural exciter/transmitter that it drives.

5.2 Separation

Dynamic separation should be measured daily. This is practical because the test can be performed from the studio without interrupting regular programming.

1. Using an AC voltmeter with VU ballistics, measure the maximum program level on either the Left or Right channel from an off-air stereo receiver.
2. Briefly interrupt the audio from the studio to that channel. The effect to mono viewers of removing one stereo channel will not be great.
3. Note the maximum value of the residual signal on that channel.
4. Subtract the residual reading from the program level.

For a well-adjusted system, expect 30-35 dB difference between program and no program.

If a period of tone modulation is available before or after the program day, it can be used for even greater accuracy.

Any decline in separation should be reason for investigation. This simple test accurately verifies not only separation but modulation sensitivity of the transmitter. Reasonable ICPM, distortion, and crosstalk performance are also indicated by this test.

5.3 ICPM

The ICPM of the visual transmitter should be checked regularly and whenever any tuning is done to the RF stages of the visual transmitter. For details on the procedure, follow the instructions provided with your video demodulator.

5.4 Modulation Sensitivity

The modulation sensitivity of the aural exciter must be checked regularly to ensure maximum stereo separation. A 2% error will reduce the maximum possible separation to 36 dB. In a real system where all other parameters are not perfect, separation is typically 3-4 dB worse than this.

How often the Bessel null measurement needs to be made depends on the specific aural exciter in use. An RCA "F" line or Larcan exciter requires checking far less often than an RCA "G" line or Harris exciter. This is because the RCA "F" line and Larcan use separate varactor diode arrays for AFC and modulation; thus, a change in AFC voltage does not shift the operating point of the modulator diode. For the "G" line and all Harris exciters, only one varactor array is used and the modulation sensitivity of the exciter will change as much as 3% over the normal operating range of the AFC. A single diode array exciter must be checked any time there is reason to suspect that the AFC voltage has varied; for instance, when a frequency adjustment is made.

5.5 Stereo Balance

Good balance between the left and right channels is important to maintaining a correct stereo perspective in viewers' homes.

Stereo balance may be checked during normal programming if it is monaural. If a stereo synthesizer is in use, switch it to mono. Monaural operation may be verified by observing the L/R CORR position of the meter on the TSG. It should be at or very near +1. Then look at the L-R modulation position—rock either the Left or Right input level control until you observe a null in the L-R meter reading. No more than a turn in either direction should be needed. If more adjustment is required, then a full alignment of the audio input levels is called for.

The procedure should be repeated with the meter in the L-R +20 dB position.

5.6 Board Swapping

Remove power before removing or inserting any circuit cards. Damage caused by removing or inserting any cards with the power on is **not** covered by any warranty. Each plug-in circuit card is functionally complete. Thus, boards can be exchanged without degrading the performance of the TSG or doing a major realignment. This is especially useful if you own two TSGs. It also means that the factory can provide exchange boards in the event any service problems arise, making it unnecessary to ship the entire unit.

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Chapter 6

Field Service

6.1 Introduction

As we all know, there may come a time when even the best-engineered equipment needs servicing. In general, Modulation Sciences recommends that you return the TSG to the factory for service. Should you find it necessary or desirable to service the TSG at your location, this section — along with the schematic diagrams for the printed circuit cards — includes the information you will need.

ONE EXCEPTION: The adjustment of the BTSC encoder card requires such sophisticated equipment that this one card **MUST** be returned to the factory for servicing.

For each of the other components of the TSG, there is a schematic diagram, a parts list and parts layouts. In this section, you will also find an overall block diagram.

6.2 Abbreviations and Symbols Used in Parts Lists

Some parts in the following list are marked with an asterisk (*). When this symbol precedes a component, it means that the part has been tested by Modulation Sciences and should not be replaced without consulting the factory.

6.3 Abbreviations Of Manufacturers' Names

3M	3M
Advancedmi	Advanced Micro
Alco	Alco Electronics Products
Allenbradl	Allen-Bradley Co.
Amp	Amp Special Industries
Amphenol	Allied Amphenol Products
Analogdevi	Analog Devices
Analog syst	Analog Systems, Inc.
Aromat	Aromat Corp.
Beauproduc	Beau Products
Belden	Belden Corporation
Berg	Berg Electronics
Bivar	Bivar, Inc.
Bourns	Bourns, Inc. Electronic Components
Bussman	Bussman Mfg. Div., McGraw-Edison Co.
Centralab	Centralab, Inc.
Dbx	dbx, Inc.
Dennison	Dennison Manufacturing Co.
Dialight	Dialight
Dzus	Dzus Fastener Co., Inc.
Fairritepr	Fair-Rite Products Corp.
Generalele	General Electric
Hewlettpac	Hewlett-Packard
Heymanmanu	Heyman Manufacturing Co.
Hhsmith	Herman H. Smith Inc.
Idi	Industrial Devices, Inc.
Ittschadow	ITT Schadow, Inc.
Jwmler	J. W. Miller
Keystone	Keystone Electronics Corp.
Leecraft	Leecraft Manufacturing Co., Inc.
Littelfuse	Littelfuse, Inc.
Magnetcoil	Magnetic Coils, Inc.

Mallory	Mallory Capacitor Co.
Military	Military
Motorola	Motorola, Inc.
Msi	Modulation Sciences, Inc.
Murataerie	Murata Erie North America, Inc.
Nationalse	National Semiconductor Corp.
Opticalele	Optical Electronics, Inc.
Panduit	Panduit Corp.
Precmonoli	Precision Monolithics, Inc.
Rca	RCA Solid State Devices
Samtec	Samtec
Sgsates	Sgsates
Sfetechnol	San Fernando Electronic Technology
Siliconix	Siliconix
Solidstate	Solid State Scientific, Inc.
Spraguelec	Sprague Electric Company
Switchcraf	Switchcraft, Inc.
Texasinstr	Texas Instruments
Toshiba	Toshiba Semiconductor USA
Tusonix	Tusonix, Inc.
Various	Various
Winchester	Winchester Electronics
Wima	Wima Div., Inter-Technical Group, Inc.
Zierick	Zierick Mfg.

6.4 Abbreviations Used In Parts Descriptions

ADJ	Adjustable
AE	Aluminum Electrolytic Capacitor
BH	Binding Head
BL	Black
BUSH	Bushing
CC	Carbon Composition Resistor
CF	Carbon Film Resistor
CM	Cable Mount
CONN	Connector
DT	Dip Tantalum
F (FEM)	Female
FH	Flat Head
INT	Internal
LH	Left Hand
LW	Lock Washer
M	Male
MC	Monolithic Ceramic Capacitor
MF	Metal Film Resistor
MINI-BAY	Mini-Bayonet Base Lamp
MOM	Momentary
MT	Mount
MY	Mylar Capacitor
nF	Nanofarad
OX	Oxide Coated
PC	Printed Circuit
pF	Picofarad
PHIL	Phillips Head
PS	Polystyrene Capacitor
PY	Polyester/Mylar Capacitor
REG	Regulator
RH	Round Head (Or Right Hand)
RND	Round
SB	Slow-Blow
SEG	Segment
SF	Stacked Film Capacitor
SM	Silver Mica Capacitor
SPAC	Spacer
SPST	Single Pole-Single Throw
SS	Solder Socket
TS	Terminal Strip
uF	Microfarad

uH
WW

Microhenry
Wire-Wrap

PARTS LIST? PRINTED CIRCUIT BOARDS

STV-784WB

G01-S00000002	1	STVF SHIELD PLATE	For STVF Board		
K04-1454A	2	NO.4 X 1/4" UNTHREAD		KEYSTONE	1454A
V01-STVA	1	STV-784 AUDIO PROCESSOR BD.			
V01-STVC	1	STV-784 CONTROL BD.			
V01-STVD	1	STV-784 DBX ENCODER MAIN BD.			
V01-STVE	1	STV-784 EXTENDER BD.			
V01-STVF	1	STV-784 INPUT / FILTER BD.			
V01-STVG	1	STV-784 STEREO GENERATOR BD.			
V01-STVS	1	STV-784 STEREO SYNC-LOCK BD.			
V02-STVH	1	STV-784 HOUSING ASSEMBLY			

PARTS LIST ? "A" CARD

MSI PART NUMBER	QTY	DESCRIPTION	REFERENCE DESIGNATOR	MANUFACTURER	MANUFACTURER PART NUMBER
V01-STVA					
A02-M105FS001	2	TRIMPOT, 10K0 20-T	RV3, RV6	BOURNS	3006-P-103
A02-S105FT001	1	TRIMPOT, 01T 10K0 FS TOP	RV1	BOURNS	3386P1-103
A02-S105US001	3	10 K UPRIGHT TRIMPOT	RV9-RV11	BOURNS	3386W1-103
A02-S204FT001	1	2 K 1-T FLAT TRIMPOT	RV8	BOURNS	3386P1-202
A02-S205FT001	1	TRIMPOT, 01T 20K0 FS TOP	RV12	BOURNS	3386P1-203
A02-S505FT001	4	50 K 1-T FLAT TRIMPOT	RV2, RV4,RV5, RV7	BOURNS	3386P1-503
A04-1002JMEG1	2	CAP 10 pF MC 10%	C7, C16	AVX	SR151A100K
A04-1006HMCH1	2	0.1 uF 50 V 20% MC	C20, C41	MALLORY	C20C104M5UICA
A04-1007HPNF1	2	1 uF 5% 63 V PY LS 10 MM	C1,C10	WIMA	MKS4RM10 1UF/5/63V 10mm
A04-1008FTNH1	1	10 uF 25 V DT	C29	SPRAGUE	199D106X0025CB1
A04-2204HMAD1	4	2.2 nF 1% 50 V MC	C5,C6,C14,C15	SFETECHNOL	G505BY222F
A04-2206HMCH1	1	0.22 uF 50 V 20% MC	C26	CENTRALAB	CZ20C224M
A04-3307FTNH1	1	3.3 uF 25 V DT	C25	AVX	TAP335M025S
A04-3902RCAF1	4	39 pF CER DISC, NPO, 0.25 LS	C2, C9, C11, C18	MALLORY	CMC390J
A04-4706HPNF2	9	0.47 uF 5% 63 V PY	C8,C17,C19,C21-C24, C27,C28	WIMA	MKS4RM7 0.47/63/5 (7.5MM)
A04-6807FTNH1	15	6.8 uF 25 V DT	C3,C4,C12,C13,C30-C40	SPRAGUE	199D685X0025CB1
B01-4148	45	GLASS DIODE	D3-D47		1N4148
B04-P3906	5	LOW POWER PNP TRANSISTOR	Q1-Q5	VARIOUS	2N3906
C01-2B0000001	5	DUAL OP AMP, PLASTIC	U7-U10, U27	TEXASINSTR	NE5532P
C01-2F0000002	15	DUAL OP AMP	U11,U13,U15-U17,U25, U26,U28-U35	NATIONALSE	LF412CN
C01-2F0000006	2	DUAL OP AMP	U1,U4	TEXASINSTR	TL072CP
C01-2F0000007	3	DUAL OP AMP	U12,U14,U24	MOTOROLA	TL082CP
C04-400000001	4	QUAD COMPARATOR	U18-U20,U23	SGSATES	LM339AN
C07-100000001	4	VCA	U2,U3,U5,U6	DBX	2151
D01-4070X0001	1	QUAD EXCL OR GATE	U21	MOTOROLA	MC14070BCP
D06-010100801	1	8-CHAN ANALOG MUX	U22	SILICONIX	DG508ACJ
E01-S40000001	1	YELLOW LED	D48	DIALIGHT	521-9176

H05-008000001	25	8-PIN EDGE GRIP SS	US1,US4,US7-US17, US24-US35	AMP	2-640463-2
H05-014000002	5	14-PIN FACE GRIP SS	U18-U21,U23	AMP	2-641261-20
H05-016000002	1	16-PIN FACE GRIP SS	U22	AMP	2-641262-20
H08-002PMW002	1	2-PIN WW STRIP	PS1	SAMTEC	TSW-102-07-GS
H08-003PMW001	2	3-PIN WW STRIP	PS2,PS3	SAMTEC	TSW-103-09-GS
H14-S00800001	4	8 MACH PIN SIL	U2,U3,U5,U6	SAMTEC	SS-108-G-2
H19-002000001	3	0.1" WW PIN JUMPER	PS1-PS3	3M	SHC-1002-001010-BOS
I03-010200201	2	DPDT MINI TOGGLE	S1,S2	ALCO	TT21NG-RA-1
K04-1547A	3	¼' X 4/40 RND SPCR		KEYSTONE	1547A
Z01-104	1	1 K ¼ W 5% CF	R125	VARIOUS	¼ W 5 % CF
Z01-105	8	10 K ¼ W 5% CF	R8,R21,R33,R46,R129, R145,R158,R165	VARIOUS	¼ W 5 % CF
Z01-106	2	100 K ¼ W 5% CF	R11,R36	VARIOUS	¼ W 5 % CF
Z01-107	3	1 M ¼ W 5% CF	R126,R149,R162	VARIOUS	¼ W 5 % CF
Z01-154	2	1.5 K ¼ W 5% CF	R99,R118	VARIOUS	¼ W 5 % CF
Z01-155	3	15 K ¼ W 5% CF	R102,R106,R144	VARIOUS	¼ W 5 % CF
Z01-204	1	2 K ¼ W 5% CF	R181	VARIOUS	¼ W 5 % CF
Z01-224	1	2.2 K ¼ W 5% CF	R109	VARIOUS	¼ W 5 % CF
Z01-225	1	22 K ¼ W 5% CF	R172	VARIOUS	¼ W 5 % CF
Z01-228	1	22 M ¼ W 5% CF	R104	VARIOUS	¼ W 5 % CF
Z01-274	4	2.7 K ¼ W 5% CF	R101,R105,R135,R143	VARIOUS	¼ W 5 % CF
Z01-336	4	330 K ¼ W 5% CF	R174-R177	VARIOUS	¼ W 5 % CF
Z01-337	4	3.3 MEG ¼ W 5% CF	R91,R110,R131,R132	VARIOUS	¼ W 5 % CF
Z01-512	2	51 OHM ¼ W 5% CF	R100,R119	VARIOUS	¼ W 5 % CF
Z02-1003	2	100 OHM ¼ W 1% MF	R98,R117	VARIOUS	¼ W 1 % MF
Z02-1004	8	1.0 K ¼ W 1% MF	R14,R17,R39,R42, R148,R151,R161,R164	VARIOUS	¼ W 1 % MF
Z02-1005	46	10.0 K ¼ W 1% MF	R1-R4,R26-R29,R59-R61, R63-R73,R75-R77,R79-R81, R83-R85,R87-R90,R93-R94, R96,R138,R140-R142,R156, R157,R160	VARIOUS	¼ W 1 % MF
Z02-1006	9	100 K ¼ W 1% MF	R58,R62,R74,R78,R82, R86,R92,R130,R154	VARIOUS	¼ W 1 % MF
Z02-1007	1	1.00 M ¼ W 1% MF	R120	VARIOUS	¼ W 1 % MF
Z02-1245	1	12.4 K ¼ W 1% MF	R95	VARIOUS	¼ W 1 % MF
Z02-1505	3	15.0 K ¼ W 1% MF	R18,R43,R173	VARIOUS	¼ W 1 % MF
Z02-1506	4	150 K ¼ W 1% MF	R6,R19,R31,R44	VARIOUS	¼ W 1 % MF

Z02-1625	1	16.2 K ¼ W 1% MF		R5	VARIOUS	¼ W 1 % MF
Z02-1695	2	16.9 K ¼ W 1% MF		R178,R179	VARIOUS	¼ W 1 % MF
Z02-2005	5	20.0 K ¼ W 1% MF	R23,R48,R150,R155,R163		VARIOUS	¼ W 1 % MF
Z02-2105	1	21.0 K ¼ W 1% MF		R30	VARIOUS	¼ W 1 % MF
Z02-2214	2	2.21 K ¼ W 1% MF		R127,R133	VARIOUS	¼ W 1 % MF
Z02-2215	2	22.1K ¼ W 1% MF		R139,R153	VARIOUS	¼ W 1 % MF
Z02-2216	1	221 K ¼ W 1% MF		R152	VARIOUS	¼ W 1 % MF
Z02-2675	1	26.7 K ¼ W 1% MF		R122	VARIOUS	¼ W 1 % MF
Z02-2745	1	27.4 K ¼ W 1% MF		R136	VARIOUS	¼ W 1 % MF
Z02-3094	1	3.09 K ¼ W 1% MF		R137	VARIOUS	¼ W 1 % MF
Z02-3325	1	33.2 K ¼ W 1% MF		R115	VARIOUS	¼ W 1 % MF
Z02-3485	4	34.8 K ¼ W 1% MF	R15,R16,R40,R41		VARIOUS	¼ W 1 % MF
Z02-3924	5	3.92 K ¼ W 1% MF	R9,R22,R34,R47,R180		VARIOUS	¼ W 1 % MF
Z02-3925	1	39.2 K ¼ W 1% MF		R107	VARIOUS	¼ W 1 % MF
Z02-4754	2	4.75 K ¼ W 1% MF		R97,R134	VARIOUS	¼ W 1 % MF
Z02-4755	1	47.5 K ¼ W 1% MF		R103	VARIOUS	¼ W 1 % MF
Z02-4756	1	475 K ¼ W 1% MF		R108	VARIOUS	¼ W 1 % MF
Z02-4992	4	49.9 OHM ¼ W 1% MF		R7,R20,R32,R45	VARIOUS	¼ W 1 % MF
Z02-4995	3	49.9 K ¼ W 1% MF		R114,R123,R124	VARIOUS	¼ W 1 % MF
Z02-5235	1	52.3 K ¼ W 1% MF		R128	VARIOUS	¼ W 1 % MF
Z02-6813	1	681 OHM ¼ W 1% MF		R111	VARIOUS	¼ W 1 % MF
Z02-6814	3	6.81 K ¼ W 1% MF		R112,R113,R116	VARIOUS	¼ W 1 % MF
Z02-6815	4	68.1 K ¼ W 1% MF	R10,R35,R146,R159		VARIOUS	¼ W 1 % MF
Z02-6816	1	681 K ¼ W 1% MF		R121	VARIOUS	¼ W 1 % MF
Z14-1005	18	10.0 K RN55 0.1% ¼ W 50 PPM	R12-R13,R37-R38,R51-R54, R166,R167,RN1(4),RN2(4)			
Z14-2215	5	22.1 K RN55 0.1% ¼ W 50 PPM		R25,R50,R55-R57	ENOX	PR1/10 0.1% 25 PPM
Z14-4994	2	4.99 K RN55 0.1% 25 OR 50 PPM		R24,R49	ENOX	PR1/10 0.1% 25 PPM

PARTS LIST ? "C" CARD

MSI PART NUMBER	QTY	DESCRIPTION	REFERENCE DESIGNATOR	MANUFACTURER	MANUFACTURER PART NUMBER
V01-STVC					
A04-1005GQNE1	1	10 nF 2.5% 33 V PS	C23	MALLORY	SXK110
A04-1005HMBG1	4	0.01 uF 50 V 10% MC	C1-C2, C7-C8	MURATA ERIE	RPE110X7R103K50V
A04-1006HMCH1	14	0.1 uF 50 V 20% MC	C3-C6, C9-C13, C18, C26-C29	CENTRALAB	CZ20C104M
A04-1007HPNF1	1	1 uF 5% 63V PY LS 10 MM	C21	WIMA	MKS4RM10 1UF/5/63V 10mm
A04-1504MCFG1	1	1.5 nF DISC	C24	SPRAGUE	5GA-D15
A04-2202UCCH1	1	22 pF DISC	C19	SPRAGUE	10TSQ22
A04-3302JMAG1	1	33 pF 100 V 10% MC	C20	CENTRALAB	CN15A330K
A04-6807FTNH1	4	6.8 uF 25 V DT	C14-C16, C22	SPRAGUE	199D685X0025CB1
B01-4148	22	GLASS DIODE	D1-D21,D33	VARIOUS	1N4150
B02-753A	1	6.2 V ZENER DIODE	D28	VARIOUS	1N753A
B04-N3904	3	NPN TRANSISTOR TO-92	Q2-Q4	VARIOUS	2N3904
B04-N4401	1	LOW POWER TRANSISTOR	Q1	VARIOUS	2N4401
BT1-4148	11	DIODE (BINNED VOLTAGE)	D22-D27, D29-D32, D34	MSI	B01-4148 (TESTED)
C01-1F0000005	1	VOLTAGE FOLLOWER	U21	NATIONALSE	LM310N
C01-2F0000002	2	DUAL OP AMP	U19-U20	NATIONALSE	LF412CN
C01-2F0000007	4	DUAL OP AMP	U11,U18,U22,U26	TEXASINSTR	TL082CP
C06-100000002	6	OPTO ISOLATOR	U12-U17	GENERALELE	4N37
D01-401300001	1	DUAL D FLIP-FLOP	U9	SOLIDSTATE	SCL4013BE
D01-401610001	2	4 BIT BINARY COUNTER	U6-U7	NATIONALSE	74C161
D01-401930001	1	BINARY UP/DN COUNTER	U5	RCA	CD40193BE
D01-4022X0001	1	8-OUT JOHNSON COUNTER	U8	RCA	CD4022BE
D01-4028X0001	1	BCD-DECIMAL DECODER	U25	RCA	CD4028BE
D01-4081X0001	1	CMOS IC QUAD 2-INPUT & GATE	U10	SOLIDSTATE	SCL4081BE
D01-4584X0001	5	HEX SCHMITT TRIGGER	U1-U4,U24	SOLIDSTATE	SCL4584BE
D06-040100101	1	ANALOG SWTCH	U23	SILICONIX	DG211CJ
H05-006000001	6	6-PIN SOCKET W/GOLD PLATE	US12-US17	TEXASINSTR	C930602
H05-008000001	7	8-PIN EDGE GRIP SS	US11,US18-US22,US26	AMP	2-640463-2

H05-014000002	7	14-PIN FACE GRIP SS	US1-US4,US9-US10,US24	AMP	2-641261-20
H05-016000002	6	16-PIN FACE GRIP SS	US5-US8,US23,US25	AMP	2-641262-20
H08-001PMS001	2	TEST POINTS	P1-P2	OXLEY	040/30P/KP2/L
H08-003PMW001	1	3 PIN WW STRIP	PS1	SAMTEC	TSW-103-03-G
H19-002000001	1	0.1" WW PIN JUMPER		3M	SHC-1002-001010-BOP
I07-001201202	1	SPDT 12 VDC RELAY	K1	AROMAT	DS1E-S-DC12V
Z01-102	1	10 OHM ¼ W 5% CF	R64	VARIOUS	¼ W 5 % CF
Z01-103	1	100 OHM ¼ W 5% CF	R77	VARIOUS	¼ W 5 % CF
Z01-104	1	1 K ¼ W 5% CF	R73	VARIOUS	¼ W 5 % CF
Z01-105	8	10 K ¼ W 5% CF	R3,R8,R26,R32-R33,R65-R66,R70	VARIOUS	¼ W 5 % CF
Z01-106	18	100 K ¼ W 5% CF	R1,R4-R6,R9,R14,R17-R19,R27-R28,R31,R34-R35,R41-R42,R45,R61	VARIOUS	¼ W 5 % CF
Z01-167	1	1.6 M ¼ W 5% CF	R46	VARIOUS	¼ W 5 % CF
Z01-183	1	180 OHM ¼ W 5% CF	R30	VARIOUS	¼ W 5 % CF
Z01-223	1	220 OHM ¼ W 5% CF	R44	VARIOUS	¼ W 5 % CF
Z01-225	8	22 K ¼ W 5% CF	R2,R7,R16,R25,R36,R74-R76	VARIOUS	¼ W 5 % CF
Z01-226	1	220 K ¼ W 5% CF	R78	VARIOUS	¼ W 5 % CF
Z01-228	3	22 M ¼ W 5% CF	R68-R69,R71	VARIOUS	¼ W 5 % CF
Z01-274	6	2.7 K ¼ W 5% CF	R12-R13,R21,R23,R39,R43	VARIOUS	¼ W 5 % CF
Z01-276	1	270 K ¼ W 5% CF	R15	VARIOUS	¼ W 5 % CF
Z01-333	1	330 OHM ¼ W 5% CF	R72	VARIOUS	¼ W 5 % CF
Z01-334	3	3.3 K ¼ W 5% CF	R22,R24,R67	VARIOUS	¼ W 5 % CF
Z01-335	3	33 K ¼ W 5% CF	R20,R57,R81	VARIOUS	¼ W 5 % CF
Z01-336	1	330 K ¼ W 5% CF	R40	VARIOUS	¼ W 5 % CF
Z01-564	1	5.6 K ¼ W 5% CF	R29	VARIOUS	¼ W 5 % CF
Z01-624	4	6.2 K ¼ W 5% CF	R10-R11,R37-R38	VARIOUS	¼ W 5 % CF
Z01-824	1	8.2 K ¼ W 5% CF	R60	VARIOUS	¼ W 5 % CF
Z02-1005	3	10.0 K ¼ W 1% MF	R56,R62-R63	VARIOUS	¼ W 1 % MF
Z02-1006	1	100 K ¼ W 1% MF	R50	VARIOUS	¼ W 1 % MF
Z02-1214	1	1.21 K ¼ W 1% MF	R58	VARIOUS	¼ W 1 % MF
Z02-1215	1	12.1 K ¼ W 1% MF	R59	VARIOUS	¼ W 1 % MF
Z02-2006	1	200 K ¼ W 1% MF 50 PPM	R49	VARIOUS	¼ W 1 % MF
Z02-2435	1	24.3 K ¼ W 1% MF	R55	VARIOUS	¼ W 1 % MF
Z02-2495	1	24.9 K ¼ W 1% MF	R52	VARIOUS	¼ W 1 % MF

Z02-3924	1	3.92 K ¼ W 1% MF	R79	VARIOUS	¼ W 1 % MF
Z02-4026	1	402 K ¼ W 1% MF	R48	VARIOUS	¼ W 1 % MF
Z02-4994	1	4.99 K ¼ W 1% MF	R80	VARIOUS	¼ W 1 % MF
Z02-4995	3	49.9 K ¼ W 1% MF	R51,R53-R54	VARIOUS	¼ W 1 % MF
Z02-8066	1	806 K ¼ W 1% MF	R47	VARIOUS	¼ W 1 % MF

PARTS LIST ? "D" CARD

MSI PART NUMBER	QTY	DESCRIPTION	REFERENCE DESIGNATOR	MANUFACTURER	MANUFACTURER PART NUMBER
V01-STVD					
A02-M105FS001	2	TRIMPOT, 10K0 20-T	RV6, RV9	BOURNS	3006P1-103
A02-M504FS001	2	5 K 20-T TRIMPOT	RV7, RV10	BOURNS	3006P1-502
A02-S104FT001	1	1 K 1-T FLAT TRIMPOT	RV3	BOURNS	3386P1-102
A02-S203FT001	1	200 OHM 1-T FLAT TP	RV2	BOURNS	3386P1-201
A02-S204FT001	2	2 K 1-T FLAT TRIMPOT	RV1, RV8	BOURNS	3386P1-202
A02-S205FT001	5	TRIMPOT, 01T 20K0 FS TOP	RV4,RV5, RV11-RV13	BOURNS	3386P1-203
A04-1002JMEG1	1	CAP 10 pF MC 10%	C54	CENTRALAB	CN15A100K
A04-1005HMBG1	4	0.01 uF 50 V 10% MC	C23,C29,C51,C55	MURATA ERIE	RPE110X7R103K50V
A04-1005JRNPF1	1	0.01 uF 5% 100 V PC	C1	WIMA	FKC2 0.01/100/5
A04-1006HMCH1	10	0.1 uF 50 V 20% MC	C4,C5,C10,C12,C14,C21,C25,C32,C37,C49	CENTRALAB	CZ20C104M
A04-1007GTNH1	1	1 uF 35 V DT	C48	SPRAGUE	199D105X0035BB1
A04-1007HPNPF1	1	1 uF 5% 63 V PY LS 10 MM	C44	WIMA	MKS4RM10 1UF/5/63V 10mm
A04-1008FTNH1	1	10 uF 25 V DT	C31		199D106X0025CB1
A04-1008FTNH1	1	10 uF 25 V DT	C30	SPRAGUE	199D106X0025CB1
A04-1503HMAG1	1	150 pF 50 V 10 % MC	C42	CENTRALAB	CN15A151K
A04-2202UCCH1	2	22 pF DISC	C6,C15	SPRAGUE	10TSQ22
A04-3302JMAG1	1	33 pF 100 V 10% MC	C43	CENTRALAB	CN15A330K
A04-3902RCAF1	1	39 pF CER DISC NPO 0.25 LS	C45	MALLORY	CMC390J
A04-3903UCBG1	4	390 pF DISC 5%	C8,C13,C17,C19	SPRAGUE	10TST39
A04-4706HPNPF2	1	0.47 uF 5% 63 V PY	C27		
A04-4708BTNH1	3	47 uF 6 V DT	C3,C9,C11	KEMET	T362B476K006AS

A04-5602HCAF1	1	56 pF 5 % COG DISC		C16	MALLORY	CEC560J
A04-6804JRN1	1	6.8 nF 5% 100 V PC		C2	WIMA	FKC26800/100/5
A04-6807FTNH1	8	6.8 uF 25 V DT	C22,C36,C38,C39,C47,C50, C52,C56		SPRAGUE	199D685X0025CB1
A04-XXXXXXXXX	2	CAPACITOR SELECTED AT TEST				
B01-4148	2	GLASS DIODE		D3,D4	VARIOUS	1N4150
C01-1B0000003	1	OP AMP, PLASTIC		U9	SIGNETICS	NE5534N
C01-2B0000001	2	DUAL OP AMP, PLASTIC		U6,U7	TEXASINSTR	NE5532P
C01-2F0000002	3	DUAL OP AMP		U8,U15,U16	NATIONALSE	LF412CN
C01-2F0000007	5	DUAL OP AMP		U5,U10-U12,U18	TEXASINSTR	TL082CP
C02-1NVARM001	1	NEG VOLT REG ADJ 1.5 A TO-220		U14	TEXASINSTR	LM337KC
C02-1PVARM002	1	POS VOLT REG ADJ 1.5 A TO-220		U13	TEXASINSTR	LM317KC
C04-200000001	1	DUAL COMPARATOR		U17	RCA	CA3290E
C07-100000001	2	VCA		U1,U2	DBX	2151
C10-100000002	2	RMS TO DC CONVERTER		U3,U4	DBX	2252
E01-S20000001	1	RED LED		D2	DIALIGHT	521-9240
E01-S50000001	1	GREEN LED		D1	DIALIGHT	521-9270
H05-008000001	12	8-PIN EDGE GRIP SS	US5-US12,US15-US18		AMP	2-640463-2
H08-001PMS001	4	TEST POINTS		TP1-TP4		
H08-002PMW002	6	2-PIN VWV STRIP		PS1-PS5,PS7	SAMTEC	TSW-102-07-G-S
H08-009PMS002	1	STRAIGHT MASCON HEADER		PS6	PANDUIT	MLSS100-9-DA
H14-S00800001	4	8 MACH PIN SIL		US1-US4	SAMTEC	SS-108-G-2
I03-010200201	1	DPDT MINI TOGGLE		S1	ALCO	TT21NG-RA-1
K04-1450A	4	4/40 X 1/4" HEX SPACER			KEYSTONE	1450A
Z01-102	2	10 OHM 1/4 W 5% CF		R99,R102	VARIOUS	1/4 W 5 % CF
Z01-103	1	100 OHM 1/4 W 5% CF		R114	VARIOUS	1/4 W 5 % CF
Z01-104	9	1 K 1/4 W 5% CF	R21,R34,R44,R48,R61,R105,R 106,R109,R110		VARIOUS	1/4 W 5 % CF
Z01-105	2	10 K 1/4 W 5% CF		R70,R112	VARIOUS	1/4 W 5 % CF
Z01-108	1	10 M 1/4 W 5% CF		R100	VARIOUS	1/4 W 5 % CF
Z01-154	2	1.5 K 1/4 W 5% CF		R14,R27	VARIOUS	1/4 W 5 % CF
Z01-228	2	22 M 1/4 W 5% CF		R51,R59	VARIOUS	1/4 W 5 % CF
Z01-336	4	330 K 1/4 W 5% CF		R91,R95,R107,R108	VARIOUS	1/4 W 5 % CF
Z01-474	2	4.7 K 1/4 W 5% CF		R73,R76	VARIOUS	1/4 W 5 % CF
Z01-512	2	51 OHM 1/4 W 5% CF		R15,R28	VARIOUS	1/4 W 5 % CF
Z01-XXX	1	RESISTOR 5% SELECTED AT TEST		R113	VARIOUS	1/4 W 5 % CF
Z02-1005	2	10.0 K 1/4 W 1% MF		R88,R89	VARIOUS	1/4 W 1 % MF
Z02-1006	2	100 K 1/4 W 1% MF		R6,R25	VARIOUS	1/4 W 1 % MF
Z02-1213	1	121 OHM 1/4 W 1% MF		R68	VARIOUS	1/4 W 1 % MF
Z02-1214	1	1.21 K 1/4 W 1% MF		R37	VARIOUS	1/4 W 1 % MF

Z02-1407	2	1.40 M ¼ W 1% MF	R53,R64	VARIOUS	¼ W 1 % MF
Z02-2003	1	200 OHM ¼ W 1% MF	R69	VARIOUS	¼ W 1 % MF
Z02-2212	2	22.1 OHM ¼ W 1% MF	R47,R60	VARIOUS	¼ W 1 % MF
Z02-2213	1	221 OHM ¼ W 1% MF	R103	VARIOUS	¼ W 1 % MF
Z02-2215	2	22.1 K ¼ W 1% MF	R101,R104	VARIOUS	¼ W 1 % MF
Z02-2875	2	28.7 K ¼ W 1% MF	R13,R29	VARIOUS	¼ W 1 % MF
Z02-3015	1	30.1 K ¼ W 1% MF	R8	VARIOUS	¼ W 1 % MF
Z02-3925	2	39.2 K ¼ W 1% MF	R45,R57	VARIOUS	¼ W 1 % MF
Z02-4992	2	49.9 OHM ¼ W 1% MF	R7,R24	VARIOUS	¼ W 1 % MF
Z02-4994	2	4.99 K ¼ W 1% MF	R90,R98	VARIOUS	¼ W 1 % MF
Z02-5496	4	549 K ¼ W 1% MF	R18,R19,R40,R41	VARIOUS	¼ W 1 % MF
Z02-6815	2	68.1 K ¼ W 1% MF	R46,R58	VARIOUS	¼ W 1 % MF
Z02-7503	1	750 OHM ¼ W 1% MF	R93	VARIOUS	¼ W 1 % MF
Z02-XXXX	18	RESISTOR 1% SELECTED AT TEST	R1,R54,R63,R74,R75,R77- R87,R92,R94	VARIOUS	¼ W 1 % MF
Z03-1005	7	10.0 K RN55 ¼ W 1% 50 PPM	R4,R16,R20,R30,R33,R39, R43	MILITARY	RN55CF
Z03-1545	1	15.4 K ¼ W 1% MF RN55 50 PPM	R5	MILITARY	RN55CF
Z03-2676	1	267 K ¼ W 1% MF RN55 50 PPM	R52	MILITARY	RN55CF
Z03-2874	1	2.87 K ¼ W 1% MF RN55 50 PPM	R3	MILITARY	RN55CF
Z03-3245	1	32.4K ¼ W 1% MF RN55 50 PPM	R36	MILITARY	RN55CF
Z03-3325	2	33.2 K ¼ W 1% MF RN55 50 PPM	R17,R42	MILITARY	RN55CF
Z03-3326	1	332 K ¼ W 1% MF RN55 50 PPM	R62	MILITARY	RN55CF
Z03-3405	1	34.0 K ¼ W 1% MF RN55 50 PPM	R2	MILITARY	RN55CF
Z03-4994	2	4.99 K ¼ W 1% MF RN55 50 PPM	R115,R116	RCD	MF55C - SORTED
Z03-7154	2	7K15 RN55 1% ¼ W 50 PPM	R49,R50	MILITARY	RN55CF
Z03-8065	1	80.6 K RN55 ¼ W 1% 50 PPM	R38	MILITARY	RN55CF
Z14-1005	9	10.0 K RN55 0.1% ¼ W 50 PPM	R9,R10,R22,R23,R56,R71, R72,R96,R97		
Z14-1825	1	18.2 K ¼ W 0.1% MF 25 OR 50 PPM	R66		
Z14-1826	4	182 K RN55 0.1% ¼ W 50 PPM	R11,R26,R31,R32		
Z14-3654	2	3.65 K RN55 0.1% ¼ W 25 PPM	R12,R35		
Z14-4994	1	4.99 K RN55 0.1% 25 OR 50 PPM	R65		

PARTS LIST ? "F" CARD

MSI PART NUMBER	QTY	DESCRIPTION	REFERENCE DESIGNATOR	MANUFACTURER	MANUFACTURER PART NUMBER
V01-STVF					
A02-M204FS001	2	2 K 20-T TRIMPOT	RV101, RV201	BOURNS	3006P1-202
A02-S203FT001	2	200 OHM 1-T FLAT TP	RV102, RV202	BOURNS	3386P1-201
A02-S205FT001	1	TRIMPOT, 01T 20K0 FS TOP	RV1	BOURNS	3386P1-203
A04-1003RSND1	4	100 pF 1% SM 500 V	C101,C102,C201,C220	ARCO	DM15FD101F03
A04-1005HMBG1	2	0.01 uF 50 V 10% MC	C120,C220	MURATA ERIE	RPE110X7R103K50V
A04-1006HMCH1	9	0.1 uF 50 V 20% MC	C3,C6,C8,C9,C12-C14,C16,C17	CENTRALAB	CZ20C104M
A04-1007GTNH1	3	1 uF 35 V DT	C1,C4,C15	SPRAGUE	199D105X0035BB1
A04-1007HPNF1	2	1 uF 5% 63 V PY LS 10 MM	C118,C218	WIMA	MKS4RM10 1UF/5/63V 10mm
A04-1502JMAG1	2	15 pF 100 V 10 % MC	C2,C5	CENTRALAB	CN15A150K
A04-3903RSND1	6	390 pF 1% SM	C103,C104,C119,C203,C204,C219	ARCO	DM15FD391F03
A04-5001UCBG1	2	5 pF DISC	C113,C213	MALLORY	CMC050C
A04-6807FTNH1	3	6.8 uF 25 V DT	C7,C10,C11	SPRAGUE	199D685X0025CB1
A05-550118021	2	5.5-18 pF TRIM CAP	CV101, CV201	TUSONIX	538-011A-5.5-18
A06-FCORE0001	4	POT CORE (2 / UNIT)	T101,T201	PHILIPS	2213P-L00-3B7
AT4-1004RSND2	18	1 nF SM	C108-C112,C114-C117,C208-C212,C214-C217	MSI	
AT4-1506JPNF1	6	CAPACITOR, 0.1%	C105-C107,C205-C207	MSI	A04-1506
B01-4148	4	GLASS DIODE	D1-D4	VARIOUS	1N4150
B04-N3904	2	NPN TRANSISTOR TO-92	Q1,Q2	VARIOUS	2N3904
B05-N15202001	2	MED POWER TRANSISTOR	Q101,Q201	MOTOROLA	MPSU05
B05-P15202001	2	MED POWER TRANSISTOR	Q102,Q202	MOTOROLA	MPSU55
BT1-4148	8	DIODE	D101-D104,D201-D204	MSI	B01-4148
C01-2B0000001	4	DUAL OP AMP, PLASTIC	U2,U104,U107,U108	TEXASINSTR	NE5532P
C01-2F0000002	2	DUAL OP AMP	U1,U106	NATIONALSE	LF412CN

C01-2F0000006	1	DUAL OP AMP	U105	TEXASINSTR	TL072CP
C01-2F0000007	3	DUAL OP AMP	U4,U102,U103	TEXASINSTR	TL082CP
C99-100000001	2	BALANCED INPUT AMP	U101,U201	ANALOGDEVI	AD524AD
D01-4070X0001	1	QUAD EXCL OR GATE	U3	SOLIDSTATE	SCL4070BE
H05-008000001	10	8-PIN EDGE GRIP SS	US1,US2,US4,US102-US108	AMP	2-640463-2
H05-014000002	1	14-PIN FACE GRIP SS	US3	AMP	2-641261-20
H05-016000002	2	16-PIN FACE GRIP SS	US101,US201	AMP	2-641262-20
H08-001PMS001	5	TEST POINTS	TP1-TP3,TP101,TP201	OXLEY	040/30P/KP2/L
H08-003PMW001	3	3-PIN WW STRIP	PS1,PS101,PS201	SAMTEC	TSW-103-03-G
H19-002000001	1	0.1" WW PIN JUMPER		3M	SHC-1002-001010-BOS
I07-001201202	2	SPDT 12 VDC RELAY	K1,K2	AROMAT	DS1E-S-DC12V
K01-A02COV001	2	20-T TRIMPOT COVER	RVC101, RVC201	BOURNS	H-83-P
V04-SCA186T2	2	TRANSFORMER	T101,T201		SCA186T2
Z01-000	2	0 OHM ¼ W 5% CF		VARIOUS	0.4" JUMPER
Z01-104	2	1 K ¼ W 5% CF	R114,R214	VARIOUS	¼ W 5 % CF
Z01-105	3	10 K ¼ W 5% CF	R18,R23,R26	VARIOUS	¼ W 5 % CF
Z01-106	2	100 K ¼ W 5% CF	R2,R9	VARIOUS	¼ W 5 % CF
Z01-107	4	1 M ¼ W 5% CF	R4,R7,R11,R14	VARIOUS	¼ W 5 % CF
Z01-155	3	15 K ¼ W 5% CF	R15,R16,R20	VARIOUS	¼ W 5 % CF
Z01-203	2	200 OHM ¼ W 5% CF	R24,R25	VARIOUS	¼ W 5 % CF
Z01-222	4	22 OHM ¼ W 5% CF	R106,R108,R206,R208	VARIOUS	¼ W 5 % CF
Z01-224	2	2.2 K ¼ W 5% CF	R3,R10	VARIOUS	¼ W 5 % CF
Z01-225	2	22 K ¼ W 5% CF	R1,R8	VARIOUS	¼ W 5 % CF
Z01-226	4	220 K ¼ W 5% CF	R6,R13,R141,R241	VARIOUS	¼ W 5 % CF
Z01-227	1	2.2 M ¼ W 5% CF	R19	VARIOUS	¼ W 5 % CF
Z01-333	2	330 OHM ¼ W 5% CF	R147,R247	VARIOUS	¼ W 5 % CF
Z01-334	2	3.3K ¼ W 5% CF	R27,R120	VARIOUS	¼ W 5 % CF
Z01-335	2	33 K ¼ W 5% CF	R146,R246	VARIOUS	¼ W 5 % CF
Z01-336	1	330 K ¼ W 5% CF	R28	VARIOUS	¼ W 5 % CF
Z01-396	1	390 K ¼ W 5% CF	R17	VARIOUS	¼ W 5 % CF
Z01-684	2	6.8 K ¼ W 5% CF	R107,R207	VARIOUS	¼ W 5 % CF
Z01-826	2	820 K ¼ W 5% CF	R5,R12	VARIOUS	¼ W 5 % CF
Z02-1005	5	10.0 K ¼ W 1% MF	R29,R104,R105,R204,R205	VARIOUS	¼ W 1 % MF
Z02-1007	4	1.00 M ¼ W 1% MF	R109,R110,R209,R210	VARIOUS	¼ W 1 % MF
Z02-1155	2	11.5 K ¼ W 1% MF	R113,R213	VARIOUS	¼ W 1 % MF
Z02-1215	2	12.1 K ¼ W 1% MF	R115,R215	VARIOUS	¼ W 1 % MF
Z02-1335	1	13.3 K ¼ W 1% MF	R21	VARIOUS	¼ W 1 % MF
Z02-1375	2	13.7 K ¼ W 1% MF	R127,R227	VARIOUS	¼ W 1 % MF
Z02-1504	4	1.50 K ¼ W 1% MF	R102,R103,R202,R203	VARIOUS	¼ W 1 % MF
Z02-1545	2	15.4 K ¼ W 1% MF	R128,R228	VARIOUS	¼ W 1 % MF
Z02-2006	2	200 K ¼ W 1% MF 50 PPM	R112,R212	VARIOUS	¼ W 1 % MF

Z02-2105	2	21.0 K ¼ W 1% MF	R123,R223	VARIOUS	¼ W 1 % MF
Z02-2434	3	2.43 K ¼ W 1% MF	R30,R121,R221	VARIOUS	¼ W 1 % MF
Z02-2875	2	28.7 K ¼ W 1% MF	R111,R211	VARIOUS	¼ W 1 % MF
Z02-4754	2	4.75 K ¼ W 1% MF	R124,R224	VARIOUS	¼ W 1 % MF
Z02-4995	1	49.9 K ¼ W 1% MF	R22	VARIOUS	¼ W 1 % MF
Z02-6043	2	604 OHM ¼ W 1% MF	R101,R201	VARIOUS	¼ W 1 % MF
Z02-7503	2	750 OHM ¼ W 1% MF	R122,R222	VARIOUS	¼ W 1 % MF
Z02-XXXX	10	RESISTOR 1% SELECTED AT TEST	R134,R135,R138,R144,R145,R234,R235,R238,R244,R245		¼ W 1 % MF
Z14-1003	2	100 OHM RN55 0.1% 50 PPM ¼ W	R142,R242	VARIOUS	RNC55 ¼ W 0.1%
Z14-1005	24	10.0 K RN55 0.1% ¼ W 50 PPM	R117,R118,R126,R130-R133,R136,R137,R139,R140,R143,R217,R218,R226,R230-R233,R236,R237,R239,R240,R243	VARIOUS	RNC55 ¼ W 0.1%
Z14-4994	3	4.99 K RN55 0.1% 25 OR 50 PPM	R119,R219,R220		
Z14-9094	4	9.09 K RN55 ¼ W 0.1% 50 PPM	R125,R129,R225,R229	VARIOUS	RNC55 ¼ W 0.1%

PARTS LIST ? "G" CARD

MSI PART NUMBER	QTY	DESCRIPTION	REFERENCE DESIGNATOR	MANUFACTURER	MANUFACTURER PART NUMBER
V01-STVG					
A02-M105FS001	1	TRIMPOT, 10K0 20-T	RV2	BOURNS	3006P1-103
A02-M204FS001	2	2 K 20-T TRIMPOT	RV3, RV4	BOURNS	3006P1-202
A02-S104FT001	1	1 K 1-T FLAT TRIMPOT	RV5	BOURNS	3386P1-102
A02-S105US001	1	10 K UPRIGHT TRIMPOT	RV1	BOURNS	3386W1-103
A04-1002JMEG1	1	CAP 10 pF MC 10%	C10	CENTRALAB	CN15A100K
A04-1006HMCH1	21	0.1 uF 50 V 20% MC	C3,C11,C19,C23,C25,C26,C29,C32,C33,C37-C48	CENTRALAB	CZ20C104M
A04-1007GTNH1	3	1 uF 35 V DT	C8,C49,C50	SPRAGUE	199D105X0035BB1
A04-1007HPNF1	1	1 uF 5% 63 V PY LS 10 MM	C14	WIMA	MKS4RM10 1UF/5/63V 10mm
A04-1009FANI1	4	100 uF 25 V AE	C20,C21,C27,C28	PAN	ECE-B1EU101Y
A04-1502JMAG1	4	15 pF 100 V 10 % MC	C1,C2,C6,C7	CENTRALAB	CN15A150K
A04-1504MCFG1	2	1.5 nF DISC	C9,C12	SPRAGUE	5GA-D15
A04-2202RSNF1	1	22 pF 5 % SM	C15	VARIOUS	DM15ED220J03
A04-3902RSNE1	2	39 pF 2% SM	C4,C13	VARIOUS	DM15FD390G03
A04-5001UCBG1	4	5 pF DISC	C22,C24,C30,C31	SPRAGUE	10TCCV50
A04-5602HCAF1	1	56 pF 5 % COG DISC	C18	MALLORY	CEC560J
A04-6802JMAG1	1	68 pF 100 V 10% MC	C5	CENTRALAB	CN15A680K
A04-6803NSND1	2	680 pF 1% SM 300V	C16,C17	VARIOUS	DM15FD681F03
A04-6807FTNH1	3	6.8 uF 25 V DT	C34-C36	SPRAGUE	199D685X0025CB1
A05-250111021	1	2.5-11 pF TRIM CAP	CV1	TUSONIX	538-011B-2.5-11
A99-000000002	2	PTC OVERCURRENT PROT	R61,R62	RAYCHEM	RXE-017
C01-1B0000001	2	HYBRID OP AMP	U13,U14	OEI	9911A
C01-1B0000002	3	FAST OP AMP	U6,U7,U10	ANALOGSYST	MA325CP
C01-1B0000004	1	OP AMP	U9	ANALOGSYST	MA332CP
C01-1F0000005	1	VOLTAGE FOLLOWER	U5	NATIONALSE	LM310N
C01-1F0000006	2	OP AMP, PLASTIC	U11,U12	TEXASINSTR	LM318P
C01-2F0000002	2	DUAL OP AMP	U4,U8	NATIONALSE	LF412CN
C01-2F0000011	1	DUAL OP AMP	U1	ANALOGDEVI	AD712JN
D01-4041X0001	1	QUAD TRUE/COMP BUFFER	U17	SIGNETICS	HEF4041BPN
D03-000000014	1	OCTAL LATCH	U22	NATIONALSE	MM74C374N

D03-00000015	1	450 nS EPROM, CERAMIC	U18	AMD	AM2716B-455DC
D05-DA0800002	2	DUAL 8 BIT MULT DAC	U19,U23	ANALOGDEVI	AD7528KN
D06-010100801	1	8-CHAN ANALOG MUX	U24	SILICONIX	DG508ACJ
D06-040100101	2	ANALOG SWTCH	U20,U21	SILICONIX	DG211CJ
H05-008000001	11	8-PIN EDGE GRIP SS	US2-US12	AMP	2-640463-2
H05-008000003	1	8-PIN MACHINE PIN SS	US1	SAMTEC	ICO-308-SGT
H05-014000002	1	14-PIN FACE GRIP SS	US17	AMP	2-641261-20
H05-016000002	5	16-PIN FACE GRIP SS	US15,US16,US20,US21,US24	AMP	2-641262-20
H05-020000002	3	20-PIN FACE GRIP SS	US19,US22,US23	AMP	2-641264-20
H05-024000002	3	24-PIN FACE GRIP SS	US13,US14,US18	AMP	2-641266-20
H08-001PMS001	4	TEST POINTS	TP1-TP4	OXLEY	040/30P/KP2/L
H08-003PMW001	2	3-PIN WW STRIP	PS1, PS2	SAMTEC	TSW-103-09-GS
I03-010100101	3	SPST MINI TOGGLE	S3-S5	ALCO	TT11DG-RA-1
I03-010200201	2	DPDT MINI TOGGLE	S1,S2	ALCO	TT21NG-RA-1
K01-A02COV001	3	20-T TRIMPOT COVER	RVC2-RVC4	BOURNS	H-83-P
K04-1547A	1	¼" X 4/40 ROUND SPCR		KEYSTONE	1547A
V04-STVGL1	1	ASSEMBLY FOR INDUCTORS	L1	MSI	STVG L1
Z01-103	4	100 OHM ¼ W 5% CF	R58,R67,R77,R78	VARIOUS	¼ W 5 % CF
Z01-104	2	1 K ¼ W 5% CF	R8,R42	VARIOUS	¼ W 5 % CF
Z01-105	2	10 K ¼ W 5% CF	R28,R76	VARIOUS	¼ W 5 % CF
Z01-106	6	100 K ¼ W 5% CF	R2,R9,R50-R53	VARIOUS	¼ W 5 % CF
Z01-107	1	1 M ¼ W 5% CF	R45	VARIOUS	¼ W 5 % CF
Z01-225	1	22 K ¼ W 5% CF	R7	VARIOUS	¼ W 5 % CF
Z01-334	5	3.3 K ¼ W 5% CF	R6,R46-R49	VARIOUS	¼ W 5 % CF
Z01-563	1	560 OHM ¼ W 5% CF	R79	VARIOUS	¼ W 5 % CF
Z02-1005	1	10.0 K ¼ W 1% MF	R80	VARIOUS	¼ W 1 % MF
Z02-1006	1	100 K ¼ W 1% MF	R34	VARIOUS	¼ W 1 % MF
Z02-1304	1	1.30 K ¼ W 1% MF	R26	VARIOUS	¼ W 1 % MF
Z02-1404	1	1.40 K ¼ W 1% MF	R30	VARIOUS	¼ W 1 % MF
Z02-1505	2	15.0 K ¼ W 1% MF	R69,R70	VARIOUS	¼ W 1 % MF
Z02-1655	1	16.5 K ¼ W 1% MF	R23	VARIOUS	¼ W 1 % MF
Z02-3244	4	3.24 K ¼ W 1% MF	R15,R17,R19,R21	VARIOUS	¼ W 1 % MF
Z02-4424	1	4.42 K ¼ W 1% MF	R32	VARIOUS	¼ W 1 % MF
Z02-4645	1	46.4 K ¼ W 1% MF	R5	VARIOUS	¼ W 1 % MF
Z02-4995	1	49.9 K ¼ W 1% MF	R25	VARIOUS	¼ W 1 % MF
Z02-8255	1	82.5 K ¼ W 1% MF	R27	VARIOUS	¼ W 1 % MF
Z02-9094	2	9.09 K ¼ W 1% MF	R1,R35	VARIOUS	¼ W 1 % MF
Z07-103	3	100 OHM 5% ½ W CC EB TYPE	R56,R60,R68	ALLENBRADL	EB TYPE ½ W 5% CC

Z14-1005	24	10.0 K RN55 0.1% ¼ W 50 PPM	R117-R118,R126,R130-R133,R136,R137,R139,R140,R143,R217,R218,R230-R233,R239,R240,R243
Z14-1005	32	10.0 K RN55 0.1% ¼ W 50 PPM	R3,R4,R10-R14,R16,R18,R20,R22,R31,R33,R37-R41,R43,R44,R54,R55,R57, R59,R63-R66,R71-R74
Z14-4994	3	4.99 K RN55 0.1% 25 OR 50 PPM	R24,R36,R75
Z20-220409S01	1	2.2K X 9 SIL RESISTOR	RN1

MSI PART NUMBER	QTY	DESCRIPTION	REFERENCE DESIGNATOR	MANUFACTURER	MANUFACTURER PART NUMBER
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V04-STVGL1

A06-BOBBIN002	1	BOBBIN, POT CORE, PC MT		PHILIPS	P1408NA100-3B7
A06-FCORE0002	1	2-PC POT CORE SET		NEMA	MW80-C
J03-S34XX0001	1	MAGNET WIRE AWG 34 HPN RED MSW		PHILIPS	BPL/DK-CLM/CM-P14
K07-000000001	1	BOTTOM PLATE		PHILIPS	WAS/10-P14/8
K07-000000002	1	WASHER		PHILIPS	CLM/CM-P14/8
K07-000000003	1	CLAMP			

PARTS LIST ? "L" CARD

MSI PART NUMBER	QTY	DESCRIPTION	REFERENCE DESIGNATOR	MANUFACTURER	MANUFACTURER PART NUMBER
V03-STVL					
A04-1005HMBG1	3	0.01 uF 50 V 10% MC	C1,C2, C4	MURATA ERIE	RPE110X7R103K50V
A04-1006HMCH1	1	0.1 uF 50 V 20% MC	C5	CENTRALAB	CZ20C104M
A04-1007GTNH1	3	1 uF 35 V DT	C3,C8,C10	SPRAGUE	199D105X0035BB1
A04-6807FTNH1	3	6.8 uF 25 V DT	C6,C7,C9	SPRAGUE	199D685X0025CB1
B01-4148	5	GLASS DIODE	D1,D17-D19,D24	VARIOUS	1N4150
B04-N3904	1	NPN TRANSISTOR TO-92	Q4	VARIOUS	2N3904
B04-P4403	3	LOW POWER TRANSISTOR	Q1-Q3	VARIOUS	2N4403
C02-1N152M001	1	-15 VOLT REGULATOR	U13	VARIOUS	uA79M15
C02-1P152M001	1	+15 VOLT REGULATOR	U11	VARIOUS	uA78M15
C02-1P501M001	1	+5 VDC 1.5 A REG TO-220 PKG.	U12	VARIOUS	uA78M05
C11-007000001	2	DARLINGTON TRANSISTOR ARRAY	U7,U8	MOTOROLA	MC1416P
D01-4022X0001	1	8-OUT JOHNSON COUNTER	U2	RCA	CD4022BE
D01-4028X0001	1	BCD-DECIMAL DECODER	U5	RCA	CD4028BE
D01-4033X0001	2	HEX SCHMITT TRIGGER	U3,U4	SGSATES	HCF4033BE
D01-4584X0001	2	HEX SCHMITT TRIGGER	U1,U6	SOLIDSTATE	SCL4584BE
E01-S20000001	1	RED LED	D23	DIALIGHT	521-9240
E01-S40000001	1	YELLOW LED	D20	DIALIGHT	521-9176
E01-S50000001	17	GREEN LED	D2-D16,D21,D22	DIALIGHT	521-9270
E03-LED000002	2	7 SEG DISPLAY (YEL) COM	U9,U10	HEWLETTTAC	5082-7663
G02-SPACER001	1	G10 STVL SPACER 1.95 x 0.625 x 0.055	S1,S2, R16	CRC CUSTOM SPACER	
G02-SPACER002	1	G10 STVL SPACER 1.80 x 0.705 x 0.055	S3,S4,S5	CRC CUSTOM SPACER	
H05-014000002	4	14-PIN FACE GRIP SS	US1,US6,US9,US10	AMP	2-641261-20
H05-016000002	6	16-PIN FACE GRIP SS	US2-US5,US7,US8	AMP	2-641262-20
H08-004PMS001	1	RT ANG MASCON HEADER	PS1	PANDUIT	HLAS100-4-A
H08-009PMS001	1	RT ANG MASCON HEADER	PS2	PANDUIT	HLAS100-9-A
I02-010100204	5	SPDT MOM PUSH SWITCH	S1-S5	ITTSCHADOW	SRU
K01-I02CAP003	5	SRU SWITCH CAP		ITTSCHADOW	SRKYELLOW
K02-000000009	19	LED MOUNT, 0.09"	D2-D16,D20-D23	BIVAR	450-090
Z01-104	2	1 K ¼ W 5% CF	R20,R21	VARIOUS	¼ W 5 % CF
Z01-105	7	10 K ¼ W 5% CF	R1,R5,R8,R10,R12-R14	VARIOUS	¼ W 5 % CF

Z01-106	4	100 K ¼ W 5% CF	R2,R3,R7,R9	VARIOUS	¼ W 5 % CF
Z01-154	2	1.5 K ¼ W 5% CF	R15,R16	VARIOUS	¼ W 5 % CF
Z01-224	1	2.2 K ¼ W 5% CF	R23	VARIOUS	¼ W 5 % CF
Z01-276	1	270 K ¼ W 5% CF	R4	VARIOUS	¼ W 5 % CF
Z01-305	1	30 K ¼ W 5% CF	R6	VARIOUS	¼ W 5 % CF
Z01-336	6	330 K ¼ W 5% CF	R18,R19,R24-R27	VARIOUS	¼ W 5 % CF
Z01-683	1	680 OHM ¼ W 5% CF	R17	VARIOUS	¼ W 5 % CF
Z08-104	1	1 K EB TYPE ½ W 10% CC	R11	ALLENBRADL	EB TYPE ½ W 10% CC
Z20-150407D01	2	1.5 K x 7 DIP RESISTOR	RN1, RN2	BOURNS	4116-001-RC

PARTS LIST ? "N" CARD

MSI PART NUMBER	QTY	DESCRIPTION	REFERENCE DESIGNATOR	MANUFACTURER	MANUFACTURER PART NUMBER
V01-STVN					
A04-1006HMCH1	1	0.1 uF 50 V 20% MC	C5	CENTRALAB	CZ20C104M
A04-6804JRNF1	2	6.8 nF 5% 100 V PC	C1,C3	WIMA	FKC2 6800/100/5
A04-6807FTNH1	2	6.8 uF 25 V DT	C6,C7	SPRAGUE	199D685X0025CB1
A04-XXXXXXXXXX	1	CAPACITOR SELECTED AT TEST			
C01-2B0000001	2	DUAL OP AMP, PLASTIC	U1,U2	TEXASINSTR	NE5532P
D06-010100801	1	8-CHAN ANALOG MUX	U3	SILICONIX	DG508ACJ
H05-008000001	2	8-PIN EDGE GRIP SS	US1, US2	AMP	2-640463-2
H05-016000002	1	16-PIN FACE GRIP SS	US3	AMP	2-641262-20
I03-010200201	1	DPDT MINI TOGGLE	S1	ALCO	TT21NG-RA-1
Z01-223	2	220 OHM ¼ W 5% CF	R2,R5	VARIOUS	¼ W 5 % CF
Z01-334	4	3.3 K ¼ W 5% CF	R23-R26	VARIOUS	¼ W 5 % CF
Z01-336	4	330 K ¼ W 5% CF	R19-R22	VARIOUS	¼ W 5 % CF
Z01-473	1	470 OHM ¼ W 5% CF	R27	VARIOUS	¼ W 5 % CF
Z14-1005	12	10.0 K RN55 0.1% ¼ W 50 PPM	R1,R3,R4,R6-R10,R13-R16	RCD	RNC55 ¼ W 0.1%
Z14-4994	4	4.99 K RN55 0.1% 25 OR 50 PPM	R11,R12,R17,R18	RCD	RNC55 ¼ W 0.1%

PARTS LIST ? "P" CARD

MSI PART NUMBER	QTY	DESCRIPTION	REFERENCE DESIGNATOR	MANUFACTURER	MANUFACTURER PART NUMBER
V03-STVP					
A04-1006HMCH1	2	0.1 uF 50 V 20% MC	C1,C2	CENTRALAB	CZ20C104M
A04-1007GTNH1	4	1 uF 35 V DT	C5-C8	SPRAGUE	199D105X0035BB1
A04-6807FTNH1	2	6.8 uF 25 V DT	C3,C4	SPRAGUE	199D685X0025CB1
C02-1NVARM001	1	NEG VOLT REG, ADJ 1.5 A, TO-220	U2	TEXASINSTR	LM337KC
C02-1P102L001	1	10 V REF	U3	ANALOGDEVI	AD581JH
C02-1P501M001	1	+5VDC 1.5 AMP REG TO-220 PKG.	U4	VARIOUS	uA78M05
C02-1PVARM002	1	POS VOLT REG. ADJ 1.5 A, TO-220	U1	TEXASINSTR	LM317KC
H08-026PMS001	1	26-PIN SOLDER HEADER	H1	3M	3429-6002
K02-000000002	1	TO-5 MOUNT		BIVAR	501-075
K02-000000003	2	ELECT. ISOLATING THE		BERGQUIST	K4-62
K02-3051	2	NO 2 SHOULDER BUSH		KEYSTONE	3051
K06-H3510NT90	1	CABLE TIE		HEYMANMANU	3510NT90
K08-STVPMB	1	MOUNTING BRACKET	MB1	MSI	STVP-MB
Z01-105	1	10 K ¼ W 5% CF	R6	VARIOUS	¼ W 5 % CF
Z01-825	1	82 K ¼ W 5% CF	R5	VARIOUS	¼ W 5 % CF
Z02-1004	1	1.0 K ¼ W 1% MF	R7	VARIOUS	¼ W 1 % MF
Z02-1213	2	121 OHM ¼ W 1% MF	R3,R4	VARIOUS	¼ W 1 % MF
Z02-1334	2	1.33 K ¼ W 1% MF	R1,R2	VARIOUS	¼ W 1 % MF

PARTS LIST ? "S" CARD

MSI PART NUMBER	QTY	DESCRIPTION	REFERENCE DESIGNATOR	MANUFACTURER	MANUFACTURER PART NUMBER
V01-STVS					
A04-1002JMEG1	1	CAP 10 pF MC 10%	C4	CENTRALAB	CN15A100K
A04-1006HMCH1	13	0.1 uF 50 V 20% MC	C1, C3, C9, C13, C18-C19, C21, C25-C30	CENTRALAB	CZ20C104M
A04-1007GTNH1	4	1 uF 35 V DT	C6, C12, C14, C23	SPRAGUE	199D105X0035BB1
A04-1007HPNF1	1	1 uF 5% 63V PY LS 10 MM	C5	WIMA	MKS4RM10 1UF/5/63V 10mm
A04-2203UCBG1	1	220 pF CER DISK 0.25 LS	C7	SPRAGUE	10TST22
A04-2703RSND1	1	270 pF 1% SM	C20	VARIOUS	DM15FD271F03
A04-3903UCBG1	1	390 pF DISC 5%	C11	ARCO	CCD391
A04-4703RSND1	1	470 pF 1 % SM 8.5 MM LS	C2	VARIOUS	DM15FD471F03
A04-6807FTNH1	5	6.8 uF 25 V DT	C8, C10, C16,C17, C22	SPRAGUE	199D685X0025CB1
A04-8203NSND1	2	820 pF 1% SM 300V	C15,C24	VARIOUS	DM15FD821F03
B01-4148	7	GLASS DIODE	D1,D2, D4-D8	VARIOUS	1N4150
B04-N3904	4	NPN TRANSISTOR TO-92	Q2, Q4-Q6	VARIOUS	2N3904
B04-P3906	2	LOW POWER PNP TRANSISTOR	Q1, Q3	VARIOUS	2N3906
C01-1F0000005	1	VOLTAGE FOLLOWER	U1	NATIONALSE	LM310N
C01-1F0000006	1	OP AMP, PLASTIC	U2	TEXASINSTR	LM318P
C01-2F0000002	1	DUAL OP AMP	U9	NATIONALSE	LF412CN
C12-200000001	1	DUAL VCO	U7	MOTOROLA	MC4024P
D01-4020X0001	1	14-BIT BINARY COUNTER	U6	SGSATES	HCF4020BE
D01-4046X0001	1	PHASE LOCKED LOOP	U12	RCA	CD4046BE
D01-4071X0001	1	QUAD OR GATE	U8	RCA	CD4071BE
D01-4538X0001	1	DUAL MONO MULTIVIBRATOR	U4	NATIONALSE	CD4538BCN
D01-4584X0001	1	HEX SCHMITT TRIGGER	U5	MOTOROLA	MC14584BCP
D06-040100101	1	ANALOG SWTCH	U11	SILICONIX	DG211CJ
E01-S50000001	1	GREEN LED	D3	DIALIGHT	521-9270
H05-008000001	3	8-PIN EDGE GRIP SS	US1, US2, US9	AMP	2-640463-2

H05-014000002	3	14-PIN FACE GRIP SS	US5, US7, US8	AMP	2-641261-20
H05-016000002	4	16-PIN FACE GRIP SS	US4,US6,US11,US12	AMP	2-641262-20
H08-001PMS001	3	TEST POINTS	TP1-TP3	OXLEY	040/30P/KP2/L
I07-001201202	1	SPDT 12 VDC RELAY	K1	AROMAT	DS1E-S-DC12V
Z01-102	1	10 OHM ¼ W 5% CF	R24	VARIOUS	¼ W 5 % CF
Z01-104	3	1 K ¼ W 5% CF	R7,R23,R39	VARIOUS	¼ W 5 % CF
Z01-105	3	10 K ¼ W 5% CF	R2,R10,R29	VARIOUS	¼ W 5 % CF
Z01-106	2	100 K ¼ W 5% CF	R32,R37	VARIOUS	¼ W 5 % CF
Z01-107	1	1 M ¼ W 5% CF	R1	VARIOUS	¼ W 5 % CF
Z01-108	1	10 M ¼ W 5% CF	R28	VARIOUS	¼ W 5 % CF
Z01-125	1	12 K ¼ W 5% CF	R38	VARIOUS	¼ W 5 % CF
Z01-156	1	150 K ¼ W 5% CF	R33	VARIOUS	¼ W 5 % CF
Z01-203	2	200 OHM ¼ W 5% CF	R25,R41	VARIOUS	¼ W 5 % CF
Z01-204	1	2 K ¼ W 5% CF	R40	VARIOUS	¼ W 5 % CF
Z01-304	1	3 K ¼ W 5% CF	R11	VARIOUS	¼ W 5 % CF
Z01-333	1	330 OHM ¼ W 5% CF	R30	VARIOUS	¼ W 5 % CF
Z01-334	2	3.3 K ¼ W 5% CF	R36,R42	VARIOUS	¼ W 5 % CF
Z01-474	3	4.7 K ¼ W 5% CF	R9,R14,R43	VARIOUS	¼ W 5 % CF
Z01-476	1	470 K ¼ W 5% CF	R35	VARIOUS	¼ W 5 % CF
Z01-513	1	510 OHM ¼ W 5% CF	R3	VARIOUS	¼ W 5 % CF
Z02-1004	3	1.0 K ¼ W 1% MF	R4-R5,R8	VARIOUS	¼ W 1 % MF
Z02-1005	5	10.0 K ¼ W 1% MF	R12,R18-R20,R26	VARIOUS	¼ W 1 % MF
Z02-1006	2	100 K ¼ W 1% MF	R16-R17	VARIOUS	¼ W 1 % MF
Z02-1505	2	15.0 K ¼ W 1% MF	R6,R15	VARIOUS	¼ W 1 % MF
Z02-1624	1	1.62 K ¼ W 1% MF	R22	VARIOUS	¼ W 1 % MF
Z02-1826	1	182 K ¼ W 1% MF	R13	VARIOUS	¼ W 1 % MF
Z02-1966	1	196 K ¼ W 1% MF	R21	VARIOUS	¼ W 1 % MF
Z02-5115	1	51.1 K ¼ W 1% MF	R34	VARIOUS	¼ W 1 % MF
Z02-6815	1	68.1 K ¼ W 1% MF	R27	VARIOUS	¼ W 1 % MF

PARTS LIST ? MAIN CHASSIS

MSI PART NUMBER	QTY	DESCRIPTION	REFERENCE DESIGNATOR	MANUFACTURER	MANUFACTURER PART NUMBER
V02-STVH					
A01-300101W01	1	300 OHM 1/2 W PRECISION AXIAL		ULTRONIX	205A+3800PPM+/-10%TC
A02-M204FS001	1	2 K 20-T TRIMPOT		BOURNS	3006P1-202
A04-1004XHNI1	10	1 nF FEEDTHROUGH		TUSONIX	2404-000-X5U0-102P
A04-1203UCBG1	2	120 pF DISC		SPRAGUE	10TST12
A04-1504XHNI1	2	1.5 nF FEEDTHROUGH		TUSONIX	357-001-X5U0-152M
A06-FBEAD0001	2	FERRITE BEAD		FAIRRITEPR	2743002111
A08-156203201	1	POWER TRANSFORMER, 56 VA		MAGNETCOIL	4-06-7-304
A09-S3AG06001	1	FUSE, SLOW BLOW, 6/10 A		LITTELFUSE	313.6
E02-282080001	1	28 V MINI-BAY LAMP		MICROLAMP	757
E04-123000002	1	AMBER NEON INDICATOR		IDI	2110A3
H02-002F00002	5	CONNECTOR, BNC FEMALE, UG1094U		AMPHENOL	31-221
H02-003M00001	2	3-PIN M PANEL MT XLR CONNECTOR		SWITCHCRAF	D3M
H04-PN0000001	1	FUSEHOLDER		BUSSMAN	HKP
H08-004CFW001	6	4-PIN CM END CONNECT W/GOLD		PANDUIT	CE100F24-4-DA
H08-009CFW001	3	9-PIN CM END CONNECT W/GOLD		PANDUIT	CE100F24-9-DA
H08-026CFC001	1	26 COND CM FEMALE PLUG	STV HARNESS ASSY	3M	3399-6026
H08-026CFC002	6	26 COND CM BP F PLUG	STV HARNESS ASSY	3M	3501-0000
H09-002GS0001	1	2 TERMINAL STRIP		HHSMITH	820
H09-005GS0001	2	5 TERMINAL STRIP		HHSMITH	847
H09-006PR0001	1	6 POS 6/32 SCREW TS		BEAUPRODUC	71706
H09-012PR0001	2	12 POS 6/32 SCREW TS		BEAUPRODUC	71712
H11-CRN160401	1	#6 CRIMP LUG		ZIERICKMAN	A3651W/.144"HOLE
H13-08P000002	6	BACK PLANE HEADER		3M	3556
H15-W02500001	6	25/50 WW EDGE CONNECTOR		WINCHESTER	HWP25CO-111
H99-001000001	1	PANEL MT BNC GND LUG		AMPHENOL	31-759
J03-GES062099	6	POLYETHYLENE EDGING, FLEXIBLE		PANDUIT	GES99F-C
J06-N026P2801	10	26-COND FLAT CABLE	STV HARNESS ASSY		
J07-P18000001	1	LINE CORD		BELDEN	17237B
J10-625000001	1	3/4" SHRINK TUBING	OVER FUSEHOLDER		
K01-A02COV001	1	20-T TRIMPOT COVER		BOURNS	H-83-P

K04-1450B	6	4/40 X 3/8" HEX SPACER	KEYSTONE	1450B
K04-1450C	6	4/40 X 1/2" HEX SPACER	KEYSTONE	1450C
K04-1451C	2	6/32 X 1/2" HEX SPACER	KEYSTONE	1451C
K04-1547A	1	1/4" X 4/40 ROUND SPACER	KEYSTONE	1547A
K05-E02000001	1	MINI-BAY LAMPHOLDER	LEECRAFT	7/06/1998
K06-D08461	4	ADHESIVE WIRE TIE MT	DENNISON	8461
K06-H3510NT90	25	CABLE TIE, 5 1/2 INCH	HEYMANMANU	3510NT90
K06-PTM2S6M	3	WIRE TIE MOUNT	PANDUIT	TM2S6-M
L02-G00000001	16	CARD GUIDE, PLASTIC	BIVAR	E700
O05-000000001	1	STRAIN RELIEF, 5N-4 BLACK	HEYMANMANU	5N-4BLACK
O10-000000001	1	SPRING (LONG)	DZUS	S3-225
O10-000000002	1	SPRING (SHORT)	DZUS	S3-200
O10-000000003	2	RETAINING SPRING	DZUS	SX520
O11-000000001	1	BLK 1/4 T LONG STUD	DZUS	AJ3-100
O11-000000002	1	BLK 1/4 T SHORT STUD	DZUS	AJ3-80
O11-000000003	1	PAWL LATCH	DZUS	DP-109-SA-(BO)
V03-STT1	1	STV-784 PWB ASSY, TERMINAL #1		
V03-STT2	1	STV-784 PWB ASSY, TERMINAL #2		
V03-STT3	1	STV-784 PWB ASSY, TERMINAL #3		
V03-STVL	1	STV-784 PWB ASSY, DISPLAY		
V03-STVP	1	STV-784 PWB ASSY, REGULATOR		
V03-UPSB	1	STV-784 PWB ASSY, POWER SUPPLY		
V04-STV784M1	1	METER	MODUTEC	STV784M1
Z02-2434	1	2.43 K 1/4 W 1% MF	VARIOUS	1/4W1%MF
Z04-3922	4	39.2 OHM 1% 50 PPM 1/2 W	MILITARY	RN65CF
Z04-7502	1	75.0 OHM 1% 1/2 W 50 PPM	MILITARY	RN65CF
Z10-103	1	100 OHM 10% 1 W GB TYPE	ALLENBRADL	GBTYPE1W10%CC

Appendix A

Alternate Bessel Null Procedures

Alternate procedures exist for doing the critical Bessel null alignment of the TSG to the aural exciter. These procedures may be desirable because an RF spectrum analyzer and/or a Tektronix 1405 Sideband Adaptor are not available.

Do not attempt to use a modulation monitor, even one designed for MTS, to set modulation sensitivity. No modulation monitor can be as accurate as the Bessel null procedure.

The Tektronix 1405 Sideband Adaptor may be easily replaced in the Bessel null setup. Any stable, low-distortion audio oscillator that can be set to 10,396 Hz and remain at exactly that frequency for the duration of the test will work. A counter is, of course, necessary to set and verify the frequency. The major advantage of the Tektronix 1405 is convenience. Its 10,396 Hz oscillator is crystal controlled and requires no special adjustment.

Contrasting this, using an RF spectrum analyzer to indicate carrier null is a classic case of overkill. We specify it in the setup because of its almost universal availability. However, a narrow-band communications receiver can be quicker and more convenient.

The simplest setup is to detect the 4.5 MHz aural IF in a demodulator on a communications receiver. A stable 4.5 MHz aural IF can be obtained from most precision video demodulators such as the Modulation Sciences *msi 320* or the Tektronix 1450 (it need not be modified for MTS). The IF of a pre-MTS monaural aural modulation monitor can also be coupled to a communications receiver. The IF frequencies range from 1 MHz to 10.7 MHz, depending on the make and model of the monitor. Using the CW or SSB bandwidth (300 Hz to 2.5 kHz), the unmodulated aural carrier is centered in the communications receiver's IF bandpass. The receiver's "S" meter provides an accurate wide-range indication of the first carrier null when ± 25 kHz deviation (100% modulation) is reached.

A wide variety of communications receivers is available to do the Bessel null adjustments. The general requirements are that they be well shielded, have a good RF/IF dynamic range, be stable, and have a narrow enough IF bandwidth to accurately resolve sidebands 10 kHz apart. At Modulation Sciences, we use a Collins R390/R391 receiver, vintage 1955. It's big, heavy, and uses lots of vacuum tubes, but it is very stable, well shielded and costs about one percent of what a modern RF spectrum analyzer does. Check with local radio amateurs when obtaining such receivers. They often know where bargains exist.

Appendix B

Eliminating Hum And Noise At Installation

With the TSG adjusted as described in the Installation Section and in the MONO mode, the noise as measured on a conventional (50 Hz to 15 kHz) modulation monitor should be the same or better than it was for mono operation before the TSG was installed. If not, some form of ground loop is the most likely cause.

First, remove all connections from the audio input strip. If the noise goes away, the trouble is in the audio input. For best RF immunity, shields should be grounded at **both** ends. As long as the source is balanced, this does not usually cause a ground loop problem. If it is necessary to reduce low-frequency noise, open the shield at the source. The other end of the shield should **always** be connected to the TSG.

If the noise and hum remain when the input is disconnected, check the composite output level. Go back to the Bessel null setup procedure and adjust until the green LED is on and the red LED is off. Be sure that the TSG is in MONO. Now, using an AC voltmeter, measure the composite output level. Use a BNC "T". If it's much less than 0.4 V RMS, increase the output of the TSG and reduce the modulation sensitivity control of the exciter. If there is no exciter control, use RF-grade 75 Ω pads, such as MINI CIRCUITS supplies, at the exciter input to reduce its sensitivity.

If hum and noise still remain, obtain a video hum removal coil. This is a standard device used to eliminate hum from video and is much favored by remote crews. If inserting such a coil between the TSG and exciter eliminates or greatly reduces the problem, it is a ground loop. The hum removal coil is an acceptable solution if it provides sufficient attenuation and is stable with changing AC power loads.

The ultimate solution to any ground problem and a good way to ensure none will ever occur is to employ the balanced line option of the TSG.

Balanced, shielded Twinax cable is used to connect the TSG to a small line receiver mounted near the aural exciter input. This technique ensures more than 100 dB of common-mode noise rejection at power line frequencies. As much as 3,000 feet of cable can be used between the TSG and the aural exciter. The system can be adapted easily to use existing Telco video Twinax.

Each TSG can drive two balanced lines without modification. With the addition of a simple external passive distribution box, you can drive as many lines as you need.

Appendix C

Level Two Alignment

If the aural exciter and transmitter have nearly perfect gain/phase characteristics, the Bessel null adjustment completes the alignment of the system. However, many transmitters, especially those not designed from the ground up for MTS, will require that the TSG compensate for their gain and phase errors.

Such compensation is simple. If you have ever aligned a stereo FM exciter, the procedure will be familiar to you. You will need a good wideband FM composite aural detector. The only instruments meeting this need are the Modulation Sciences *msi 320* Precision Video Demodulator, the Tektronix 1350 demodulator, and the discontinued Tektronix 1450-1 demodulator modified for MTS. The HP 8901A, 8901B, or 8902A are also excellent demodulators and are available from many equipment rental companies. However, the HP gear will not work in the presence of visual RF. If this equipment is not available, you may use an FM broadcast modulation monitor (wideband monaural) if either its local oscillator is moved in frequency or an external balanced mixer and oscillator are rigged to heterodyne the aural carrier into the monitor. See the article "Is Your Transmitter Stereo Ready?" which is inside the front cover of this manual.

Connect the demodulator after the point where the aural and visual are combined (post diplexer, filterplexer, etc.) and turn off the visual transmitter.

If you use a Modulation Sciences *msi 320* demodulator or a Tektronix 1450-1 demodulator, the visual transmitter can remain on. For best results the *msi 320* should be operated in the quasi-parallel (Q-P) mode and the 1450-1 should be operated in the "split mode".

Connect an audio oscillator to the Left channel input of the TSG. Put the TSG into STEREO mode and set the switches on the RF shield panel as follows:

"A" card:	Flat Bypass
"D" card:	Bypass
"G" card:	L-R Level: Test
	Pilot: Off

All other switches must be down.

Set the signal generator to approximately 1 kHz and set the level to produce a reading of about 60 in the L+R MODULATION position of the meter (top scale).

Because of capacitive effects, the connection of the demodulator wideband output to the oscilloscope is somewhat critical. A short length (no more than six feet) of 75 Ω coax should be used between the demodulator output and the scope. If the demodulator output is 75 Ω , use 75 Ω coax with a termination at the scope end. Never use a 10x probe to make separation measurements.

Adjust the scope to produce a trace similar to Figure C-1. Note the flatness of the baseline. For comparison, look at the misaligned generator pattern shown in Figure C-2. Tweak the L-R LEVEL for the flattest baseline. Increase the gain of the scope to obtain a magnified view of the baseline, as in Figure C-3.

This test places extra demands on the overload characteristics of the oscilloscope's vertical amplifiers. The peak-to-peak signal may be as much as 20 times the maximum visible signal on the CRT. Most plug-in style vertical amplifiers for Tektronix scopes such as the 5000 and 7000 series seem to work fine. The same is true for lab-grade portables. However, beware of some of the less expensive "service" type scopes, as they seem prone to overload and the attendant phase shift.

The procedure for measuring separation is as follows:

1. Determine the actual peak to peak amplitude of the entire waveform. E1 in figure C-1 is the total peak-to-peak value.
2. Increase the sensitivity of the vertical channel to expand the baseline as in Figures C-3 and C-4.
3. Determine the peak-to-peak amplitude of the baseline offset as shown in Figure C-4.

Use the following formula to calculate separation:

$$\text{Separation (dB)} = 20 \log_{10} (E2/E1)$$

Move the audio oscillator to the right channel input of the TSG and repeat the procedure. The separation should be approximately equal with either the Left or Right channels driven. If not, find a compromise adjustment of L-R LEVEL that produces the best reading in both channels.

Now check the separation across the audio spectrum from 50 Hz to 14 kHz. If at any point you note insufficient separation, you can isolate it to either the transmitter or stereo generator by moving the scope to the output of the TSG and re-balancing L-R LEVEL. If you cannot produce separation of greater than 40 dB directly out of the TSG, the problem is in the generator. If you obtain acceptable performance from the TSG, the problem is in the aural exciter/transmitter or the RF demodulator.

After you optimize separation, you can adjust pilot phase. Note that pilot phase can be strap-selected to be exactly correct by a jumper on the TSG "G" card. However, this does not allow for transmitter compensation. The strap is factory set to enable the PILOT PHASE adjustment. If in the course of the test you should find that this control does not appear to have any effect, verify that the strap is connected to permit adjustment.

The general test setup for pilot phase is similar to that for separation. Set the audio oscillator to 500 Hz and drive the Left channel of the TSG. The TSG should be in the STEREO mode and the switches on the RF shield panel should be set as follows:

"A" card:	Flat Bypass Audio Processing
"D" card:	Bypass
"G" card:	L-R Level: Test
	Pilot: On
	L+R: Off
	L-R Signal: Test
	L Only

Adjust the oscillator level so that L-R MODULATION reads 60%.

Adjust the scope for a display similar to Figure C-5. Adjust the PILOT PHASE control until the tips point to one another. Figure C-6 shows an expanded version of Figure C-5 and Figure C-7 shows incorrect alignment.

Appendix D

Level Three Alignment

A level three alignment is really a complete systems check — TSG, aural exciter, transmitter, and diplexer. It is **not** necessary to do a level three alignment of a TSG to achieve full TSG performance.

The unique aspect of this alignment procedure is that it evaluates the performance of the BTSC (dbx) encoder and decoder. However, the tests can, and should, be run in equivalent mode as well as BTSC mode. If the difference between these modes is not clear, we suggest reading “Understanding MTS Equivalent Mode” by Eric Small. A copy of the paper is included inside the front cover of this manual.

All instructions are written for BTSC mode testing. To make Equivalent mode measurements, place the D card in BYPASS and the SRD-1 decoder in EQUIV. Bear in mind that these are systems checks and the results make no distinction between deficiencies originating in the generator or decoder. Therefore, it must be possible to verify the performance of the stereo decoder against Appendix D of *BTSC Recommended Practices*. That is easily done with the Modulation Sciences SRD-1 decoder, but it may be more difficult or impossible with any other type of stereo decoder.

Among other major test equipment, you will need: a Modulation Sciences msi 320 demodulator, a Tektronix 1450-1 demodulator modified for MTS, or an HP 8901A or equivalent; a Modulation Sciences SRD-1 Stereo Reference Decoder, and a low-frequency spectrum analyzer with a tracking generator. Acceptable analyzers include a Tektronix 7L5 or 5L4N or an HP 3585A. The test setup also provides a convenient method to measure various BTSC receivers by substituting them for the demodulator/decoder combination.

Figure D-1 shows the connection of the test equipment. For tests to show compliance to BTSC, the pre-emphasis/de-emphasis should be off. BTSC specifies that the M channel (L+R) modulation should be 10% for making separation measurements. Modulation Sciences suggests that measurements also be made at 10 dB above and below this level (3.15% and 31.5% M channel modulation).

The procedure to measure separation with, for example, the left channel being driven, is as follows:

1. Follow the SRD level alignment instructions provided with the unit.
2. Set the spectrum analyzer to sweep from 20 Hz to 15 kHz if possible. For some analyzers, it may be necessary to use a 0 to 20 kHz sweep.
3. Adjust the level of the tracking oscillator to produce the desired M channel (L+R) modulation (typically between 3% and 35%). Ignore the transient produced when the sweep resets. Use a sweep time of 3 seconds or longer and set the level during the middle of the sweep. To make measurements with pre-emphasis, first set the level with pre-emphasis off, then measure with pre-emphasis on. If pre-emphasis is on, do not set the low-frequency L+R modulation above 10% or clipping will occur at high frequencies.
4. Set the audio processor ("A" card) to BYPASS (switch up). Pre-emphasis may either be off (FLAT) or on (75 MICROSEC). All other switches should be down if testing is in the BTSC mode. If you are performing equivalent mode tests, the "D" card must be in BYPASS.
5. Be certain that the de-emphasis switch on the SRD-1 is pushed in only if the pre-emphasis is active on the TSG.
6. Display the left channel on the spectrum analyzer. Adjust the analyzer gain so that the trace is at the top of the screen. The display should look like the top line in Figure D-2. This is the frequency response of the system. If the spectrum analyzer has a storage method, save this trace.
7. Shift the input of the spectrum analyzer to the Right (undriven) channel. The display should look like the lower trace in Figure D-2 This is the swept separation of the system.

Try changing various parameters of the system while observing separation in BTSC mode. L-R GAIN produces the most dramatic changes, closely followed by composite level. PILOT PHASE generally produces the smallest change. Of course, by exchanging the Left and Right channels, separation can be measured with the Right channel being driven.

By connecting the input of the low-frequency spectrum analyzer to the composite output of the TSG, it can also be used to verify pilot injection, subcarrier suppression, SAP injection, and PRO injection. Remember, however, when viewing the L-R subchannel in the BTSC mode, there is considerable noise modulation under no-signal conditions. This is a normal condition and the noise will vanish in the Equivalent mode.

Manufacturer's Limited New Equipment Warranty And Disclaimer

We warrant the equipment sold shall be free from defects in materials and workmanship under normal use and service for a period of three (3) years from the date of delivery when properly installed. Our sole obligation under this warranty shall be limited to repair or replacement at Our option of any such part or parts of the product which Our examination shall disclose to Our satisfaction to be defective.

If you wish to have warranty services performed at Our facilities, You shall obtain from Us, in advance, permission to return the equipment and shall ship it properly packed with transportation and insurance prepaid. Service performed at Our facilities under this warranty shall include parts plus labor. It is expressly agreed that Our obligation to repair and replace defective parts is Your sole and exclusive remedy.

THE WARRANTY TO REPAIR OR REPLACE DEFECTIVE PARTS IS EXPRESSLY IN LIEU OF AND HEREBY IN DISCLAIMER OF ALL OTHER EXPRESS WARRANTIES, AND IS IN LIEU OF AND IN DISCLAIMER AND EXCLUSION OF ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AS WELL AS ALL OTHER IMPLIED WARRANTIES, IN LAW OR IN EQUITY, AND OF ALL OBLIGATIONS OR LIABILITY ON OUR PART. THERE ARE NO WARRANTIES WHICH EXTEND BEYOND THE DESCRIPTION HEREOF.

Our liability does not include any labor charges for replacement of parts, adjustments, repairs, or any other work done outside our factory, unless such work is authorized in writing by Us. Our obligation to repair or replace shall not apply to any equipment which shall have been repaired or altered outside Our factory in any way, subjected to negligence, misuse, unauthorized alteration or abuse, or damaged in transit.

OUR LIABILITY HEREUNDER SHALL NOT INCLUDE LOSSES OF ANTICIPATED PROFITS OR SPECIAL INCIDENTAL OR CONSEQUENTIAL DAMAGES.