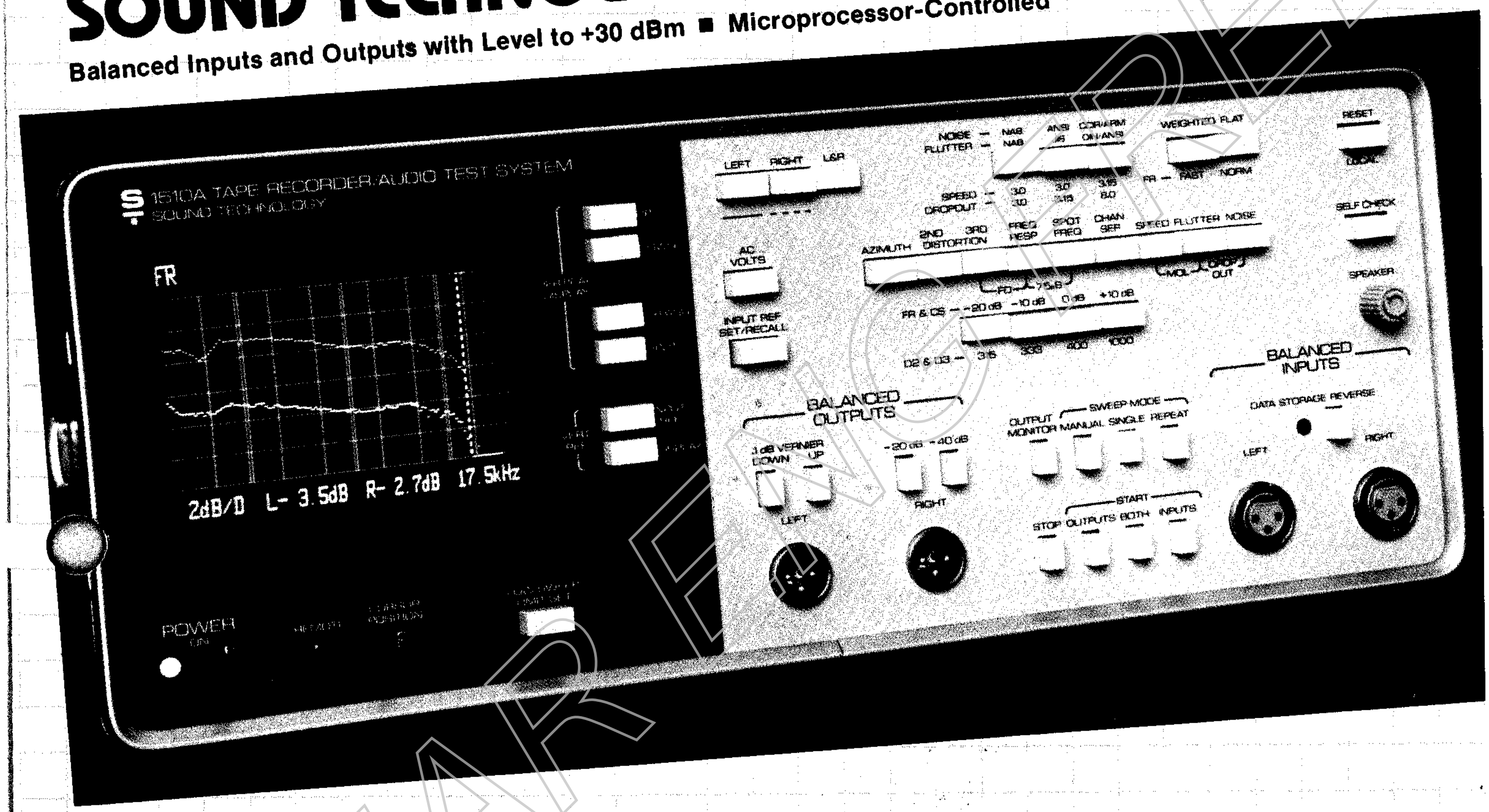
MODEL 1510A
TAPE RECORDER/AUDIO TEST SYSTEM
SOUND TECHNOLOGY

Balanced Inputs and Outputs with Level to +30 dBm ■ Microprocessor-Controlled



WITH THIS MICROPROCESSOR-CONTROLLED INSTRUMENT YOU CAN AUTOMATICALLY MEASURE AND DISPLAY:

- AC VOLTS
- PHASING
- 2nd HARMONIC DISTORTION VS LEVEL
- 3rd HARMONIC DISTORTION VS LEVEL
- FREQUENCY RESPONSE
- CHANNEL SEPARATION
- MOL - MAXIMUM OPERATING LEVEL
- NOISE, COMPOSITE AND SPECTRAL
- DELTA SPEED AND DRIFT
- WOW AND FLUTTER, AVERAGE AND SPECTRAL
- DROPOUT VS TIME

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MODEL 1510A

TAPE RECORDER/AUDIO

TEST SYSTEM

OPERATOR'S MANUAL

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SECTION 1

OPERATIONAL CHARACTERISTICS

1-1 GENERAL

The 1510A contains all the analog signal sources, amplifiers, demodulators, detectors, and filters needed to completely test, adjust, and calibrate audio tape recorders. The 1510A is automatically controlled by microprocessor-based circuitry. The measurement values are stored in digital memory and displayed on a raster-scan CRT. The 1510A can measure, store and display data from two channels. This makes it completely automatic for two-channel or stereo audio tape recorders, and very useful for multi-channel recorders and for other audio equipment. Performance specifications are given below.

1-2 SPECIFICATIONS

A. INPUT/OUTPUT

Response	20 Hz to 40 kHz ± 0.1 dB
Differential Residual Noise	< 50 μV
Common Mode Rejection	> 60 dB at 60 Hz
3 dB Bandwidth	> 100 kHz
Input Impedance	100 kohms ±1%
Maximum Input Level	42 Vrms (+34 dBm)
Output Impedance	50 ohms ±1%
Maximum Output (600 ohm Load)	+30 dBm on DIST (distortion) and MOL (Maximum Output Level) +20 dBm on FREQ RESP & CHAN SEP +10 dBm on AC VOLTS, SPEED FLUTTER & DROP-OUT -10 dBm on AZIMUTH
Output Level Controls	0.1 dB vernier with a 20 dB range and a 20, 40 or 60 dB attenuator
Channel Selection	LEFT only - Signal at LEFT output Measures signals at LEFT input RIGHT only - Signal at RIGHT output Measures signals at RIGHT input LEFT and RIGHT - Signals at both outputs Measures signals alternately at both inputs except for azimuth where both channels are measured simultaneously.

B. AC VOLTS

Response	True rms with -3 dB bandwidth from 5 Hz to 115 kHz
Accuracy	±2% of reading
Autoranging	Full scale readings of 100 V, 30 V, 10 V, 3 V, 1 V, 300 mV, 100 mV, 30 mV, 10 mV, 3 mV, 1 mV, 300 µV, and 100 µV
Residual Noise	<100 µV
Display	Vertical bar graph Digital readout of AC VOLTS (3 digits) Digital readout of AC VOLTS in dBm (± .1 dB)

C. AZIMUTH (Phase Meter)

Measurement Frequencies	2.8, 5.7, 15.8 kHz, ±1 kHz Min. and 11.8 kHz, +1/-4 kHz Min.
Cycle Time	0.1 sec thru the four frequencies
Measurement Range	±180 degrees of electrical phase
Accuracy	±2 degrees electrical phase at 15.8 kHz (eqv. to 1/26 minutes of arc in cassette format)
Display	Dynamic: Bars show instantaneous phase error between L and R channels for each frequency. Digital readout of error at measured frequencies.

D. DISTORTION

Display	2nd or 3rd harmonic distortion versus the input level
Fundamental Frequencies	315, 333, 400 or 1000 Hz
Accuracy	±5% of reading
Maximum Residual Distortion	Output: <0.01%. Input: <0.01% (3rd Harmonic) <0.02% (2nd Harmonic)
Input Level	Input from recorder: Display shows distortion verses input level in 1 dB steps.
Output Level	Output to recorder: +20 to -10 dB in 0.5 dB steps referred to preset output LOW SWEEP LIMIT available to reduce lower sweep range

Sweep Time	Less than 40 seconds from +20 to -10 dB Can be terminated with LOW SWEEP LIMIT or STOP button
Display	Trace shows plot of distortion verses input level Digital readout of distortion in both percent and dB
Minimum Input S/N Ratio	The noise at the harmonic of the frequency tested must be at least 10 dB lower than the distortion level to meet the 5% accuracy specification.

E. FREQUENCY RESPONSE

Frequency Range	Stepped sweep from 40 kHz to 20 Hz LOW SWEEP LIMIT can be used to reduce frequency sweep. A selectable single frequency output is available in MANUAL MODE.	
Freq. Resolution	±3%	
Minimum Input S/N Ratio	20 dB	
Maximum Input Signal Slope	60 dB per octave in NORM mode 30 dB per octave in FAST mode	
Sweep Time	FAST mode:	Approx. time:
	40 kHz to 20 Hz 40 kHz to 1 kHz	34 secs 8 secs
	NORM mode:	Approx. time:
	40 kHz to 20 Hz 40 kHz to 1 kHz	46 secs 16 secs
Output Level Offsets	+10, 0, -10, -20 dB ±0.1 dB	
Display	Level of 123 discrete frequencies Digital frequency readout	

F. SPOT FREQUENCY RESPONSE

Frequency Spots	20, 50, 100, 200, 500, 1 k, 2 k, 5 k, from 10 k to 20 k, 40 kHz
Sweep Time	12 seconds fast, 17 seconds normal
Other Parameters	Same as FREQUENCY RESPONSE test

G. CHANNEL SEPARATION

Frequency Range	Sweep from 20 kHz to 20 Hz with 1/3 octave resolution
Residual Noise	$< 100\mu V$
Amplitude Accuracy	± 1 dB
Output Level Offsets	+10, 0, -10 and -20 dB ($\pm$0.1 dB)
Display	Trace shows channel separation in 1/3 octave steps. Digital frequency readout

H. SPEED

Measurement Time	10 to 600 seconds
Range	$\pm$ 4% speed error
Output Frequency	3.0 kHz (NAB, JIS), or 3.15 kHz (DIN, ANSI), $< \pm 0.005\%$
Speed Error Accuracy	Instantaneous: $< \pm 0.05\%$ 10 second avg: $< \pm 0.005\%$
Display	Trace shows 10 second averaged speed error verses time Digital readouts of both instantaneous and 10 second averaged speed error

I. FLUTTER

Output Frequency	3.0 kHz (NAB, JIS), or 3.15 kHz (DIN, ANSI), $< \pm 0.005\%$
Autoranging	0.03% to 10% full scale
Accuracy	$\pm$5% of reading
Residual Flutter	0.005% or less
Detection, Weighting, and Display Dynamics	Per NAB, JIS, or DIN/ANSI standards (see Tables 2 & 3 and Figures 3, 4 & 5)

Display	Vertical bar graph Digital readout shows 2 Sigma signal (smoothed, 95% of peak). 1/3 octave spectral display available as option.

J. DROPOUT

Output Frequency	3.0, 3.15 or 8.0 kHz ±5%
Measurement time/range	1000 secs. in 20 sec steps/0 to 253 drop-outs per 20 secs
Standard	I.E.C. #94, Sept. 1981

K. NOISE

Residual Noise (referred to 1 volt)	Flat: <-92 dB NAB Weighted: <-97 dB
Response (Flat Mode)	-3 dB frequencies are 20 Hz and 20 kHz
Detection, Weighting, and Display Dynamics	Per NAB, ANSI, or CCIR/ARM standards CCIR 468-2 available as option (replaces CCIR/ARM).
Output	Floating, 50 ohms
Accuracy	±5%
Display	Autoranging vertical bar graph with digital readout, referred to input reference level (1/3 octave spectral display available as option)

L. MOL (Maximum Output Level)

Measures input level verses output level in 1 dB steps from +20 dB to -10 dB at a chosen frequency.

Measurement/Display	Output level versus input amplitude compression
Frequencies	Selectable pseudo 1/3 octave frequencies from 40 Hz to 40 kHz
Sweep Time	33 sec from +20 dB to -10 dB Sweep can be terminated at any level with LOW SWEEP LIMIT or STOP button.
Accuracy	± 5% of reading

M. GENERAL

Rear Panel Outputs	Composite industrial video signal, non-interlacing scan, 1V p-p, ±6 dB, 75 ohm, negative sync, 2% overscan Demodulated flutter signal, $<$15 Vp-p, 1 k ohm
Power	100, 120, 220, 240V +7%/-14%, 48-66 Hz, 120 Watts
Dimensions-H.W.D.	7.0 x 17.0 x 16.4" (18 x 43 x 42 cm)
Weighted-Net/Shipping	34 lbs. (15.5kg)/43 lbs. (19.5 kg)
Environmental	+50° to +104° F (+10° to +40° C), 90% RH

1-3 OPERATIONAL STATES

The 1510A has five distinct modes or operational states. These are Pre-Test, Active-Test, After-Test, Self-Check and Output monitor states. A familiarity with these states and how to move from one to another will aid in getting the maximum benefit from the instrument. Note that words in capital letters are used to identify the buttons on the front panel.

When in the Self Check state, the 1510A executes a functional check of most circuits and displays the result. The 1510A enters the Self Check state from any other state simply by pressing the SELF CHECK button. The 1510A remains in this state until the RESET button is pressed at which time the AC VOLTS test is entered.

The Output Monitor state is used primarily to verify that the 1510A output signals are at the desired level for any selected test function or condition. When in this state, the 1510A outputs a test signal and the level of this test signal is monitored and displayed. The Output Monitor state is entered whenever the OUTPUT MONITOR button is pressed. This button is mechanically interlocked with the SWEEP MODE buttons.

The Test States are the normal operating states, and are divided into Pre-Test, Active-Test, and After-Test states. The 1510A is in the Pre-Test state whenever you have come from one test to a different test or power-on. When in this state, useful pre-test information is displayed on the video display, no test signals are present at the 1510A outputs, and the 1510A measurement circuits are inactive. From the Pre-Test state, the 1510A moves to the Active-Test state whenever the START OUTPUTS and/or START INPUTS buttons are pressed. When in this state, "O" (Output) and/or "I" (Input) labels are displayed in the upper left corner of the CRT and the measured data is displayed as it is obtained.

When the STOP button is pressed, or when a single sweep has been completed and in single mode, the 1510A moves from the Active-Test state to the After-Test state. In this state, a cursor appears on the display for the graphed tests (for example; frequency response) and can be used to accurately read data on one or both channels at any point on the graph. Other buttons in the display area are active in this state to display and readout data obtained during the Active-Test state. The data in the memory (the displayed data) will be deleted from the memory when any one of the test buttons (AC VOLTS, AZIMUTH etc.) is pressed. Data in the memory acquired during the Active-Test state will be lost when the following buttons are pressed: RESET; SELF CHECK; MANUAL MODE; OUTPUT MONITOR. In frequency response the NORM and FAST buttons will not destroy the data in memory. When the START OUTPUTS or START INPUTS are pressed, the channel selected will lose the displayed data. The data in the other channel will be retained except as noted above. If the L & R button is selected when the START INPUTS or START OUTPUTS buttons are pressed, all data will be lost.

For swept measurements, the 1510A will automatically terminate measurements and go to the After-Test state at the end of a test sequence, if in single mode. Also, the 1510A will automatically switch the measurement circuits from one channel to the other as required if the L&R button was pressed before starting the test. For frequency response, the test used to confirm the end of the sweep or channel switch time is a match between the last-measured-frequency and the LSL-plus-one-window frequency, followed by a match between the last-measured-frequency and the LSL frequency.

The use of only one frequency comparison would make the 1510A too susceptible to false indications caused by random signals such as IM products from the recorder being tested.

There will be conditions where this test is not met because of limited frequency response or noise. For such a condition, make measurements only on the LEFT or RIGHT (not L&R) channels, and terminate the test by pressing STOP, or setting LSL higher.

1-4 CONTROLS

The following paragraphs describe the functions of the switches on the front panel of the 1510A. Refer to the front panel to locate these various controls or see Figure 7 page 37.

A. VIDEO DISPLAY CONTROLS

1. CURSOR POSITION Switch: Momentary operation moves the cursor left or right to a particular point on the display for reading frequency and level measurements. This switch has two funtions. It is either a controller of the output level or frequencies when the 1510A is in the manual mode, or, in the after-test state, it is an indicator of the frequency or level of the information plotted on the display. Other uses of the cursor will be found in VERT-REF-DISPLAY and the LSL (LOW SWEEP LIMIT) switch section. Detailed cursor uses are described throughout this section.

2. VERTICAL DISPLAY Switches: These switches aid data viewing but do not change the measured and displayed values. The switches are not active during the active-test state with the exception of the EXPAND and SPLIT buttons which are active during frequency response tests. The UP and DOWN buttons reposition the data that is outside the limits of the screen so it can be seen. The data moves one vertical division each time the UP or DOWN button is pressed. For manual frequency response tests, the UP and DOWN buttons act as frequency vernier controls; and for the distortion tests these buttons act as a level vernier control. The SPLIT button separates the displayed right and left channel traces to permit better viewing of the data when the traces are very close to each other.

The EXPAND button changes the vertical scale factor (See Table 1 for scale factors). When this function is activated, the data on the graph is expanded from the center horizontal line of the display. When the SPLIT button is activited, the reference line is moved one horizontal line up for the right channel and one horizontal line down for the left channel.

3. VERT REF - DISPLAY Switch: Changes the displayed reference level from the value stored in memory to the point on the displayed curve that the CURSOR intersects.

This point becomes the normalized value and all other points on the curve are referenced to this value. The original data reference is restored by pressing VERT REF-INPUT REF. The VERT REF buttons perform the normalization function on all tests that have a graph plotted. For the SPEED test the normalized graph becomes a Drift graph.

Table 1

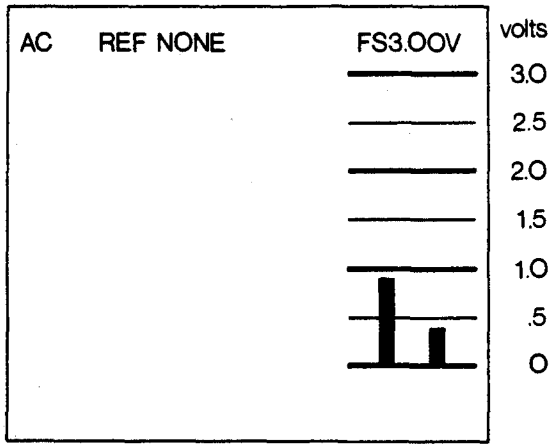
	Normal	Expand	
Distortion	10	2	dB/Div
Frequency Response	10	2	dB/Div
Channel Separation	10	2	dB/Div
Speed	0.2	0.02	%/Div
Flutter	.010	.006	%/Div
Noise	10	2	dB/Div
MOL	5	1	dB/Div
Drop Out	10	2	DO/Div

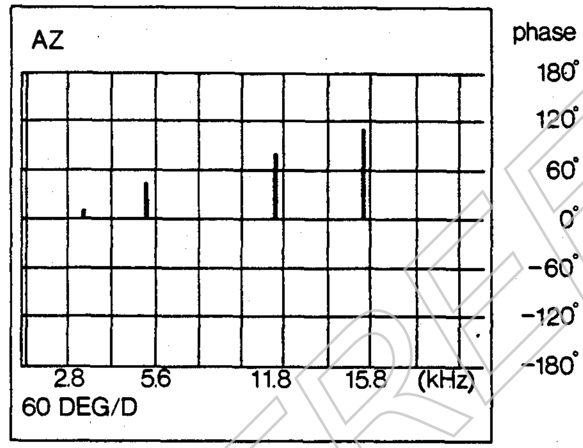
4. LOW SWEEP LIMIT (LSL) Switch: The output of the 1510A in any sweep mode starts from the highest frequency or the highest voltage level. The LSL button limits the lower sweep range. This function can be activiated when the 1510A is in the Pretest or After Test state and when the test is one that either the SINGLE or REPEAT modes are used. This includes the noise and flutter tests with the 1/3 octave filter option. The Low Sweep Limit is then defined as the position of the CURSOR at the time the LSL Switch is pushed. The letters LSL will appear at the top of the display screen with the level or frequency of the low sweep limit following. This LSL value will remain in memory for that particular test until it is either changed or the power is removed from the 1510A. If this button is pressed during an active test, the test will reset.

5. LEFT, RIGHT and L&R Switches: When the 1510A is in the After-Test state, these switches operate as display control switches. Press LEFT to display the data that was previously collected and stored in the left digital memory. RIGHT displays the data stored in the right channel memory, and L&R displays both memories simultaneously. To aid in the identification of data from the two channels, the data in the left is always displayed as a solid line and the data in the right channel as a dashed line.

B. TEST PARAMETER CONTROLS

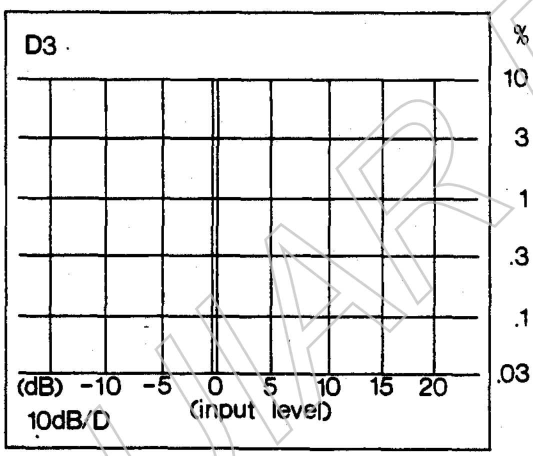
NOTE: Some of the graticules used in the following test are shown in Figure 1.

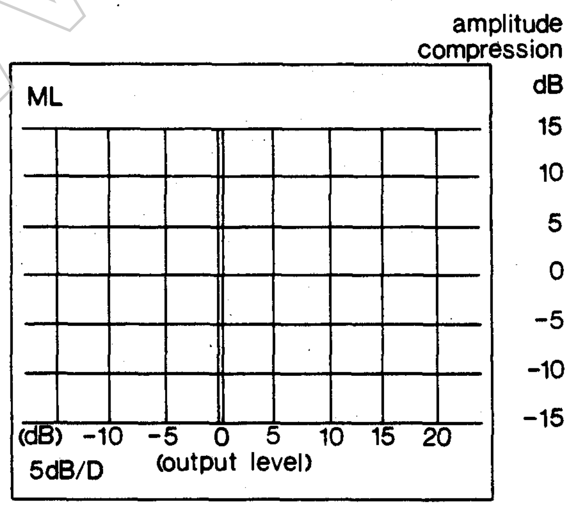




A. AC VOLTS - Bars that indicate the input RMS Volts extend vertically from the zero volt line. There are full scale units of ones or threes. The value of the lines on the bar graph is shown at the right of the AC Volt display.

B. AZIMUTH - The phase difference between the Right and Left inputs are plotted with vertical bars that start from the 0 degree line. The frequency of the bars is shown at the bottom of the graph.

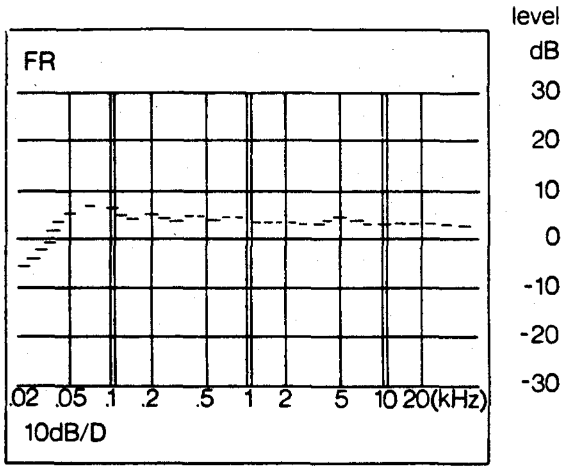


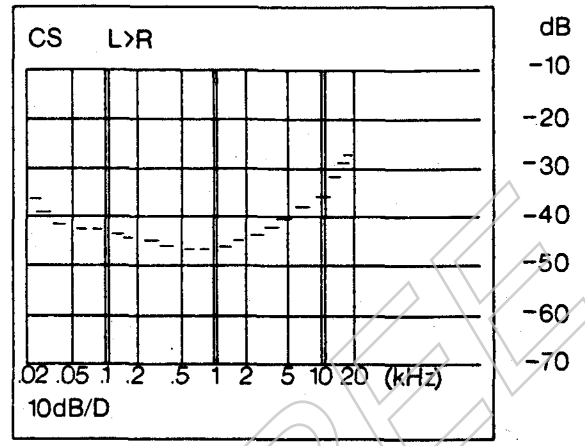


C. DISTORTION - Plot of distortion versus the input level. The amount of distortion for a certain level is along the right in %.

D. MOL - The amplitude compression of the signal at the 1510A input is measured versus the 1510A output level.

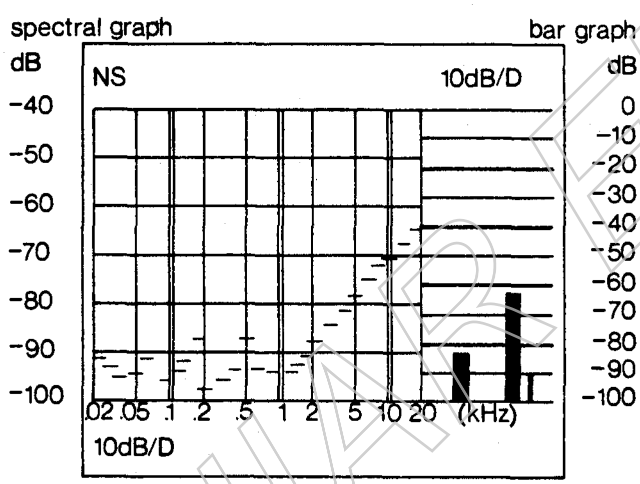
Part of Figure 1.

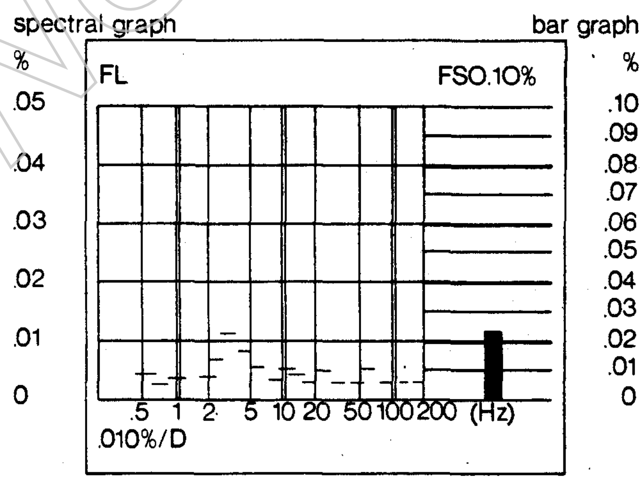




E. FREQUENCY RESPONSE - The levels are with respect to the Input Reference. The offset buttons will change the level values by the amount indicated on the buttons.

F. CHANNEL SEPARATION - This graticule shows the separation in dB of the signal on the LEFT channel to the noise and cross talk on the RIGHT channel.

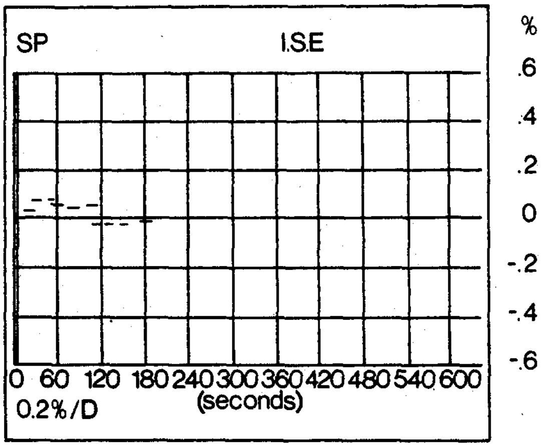


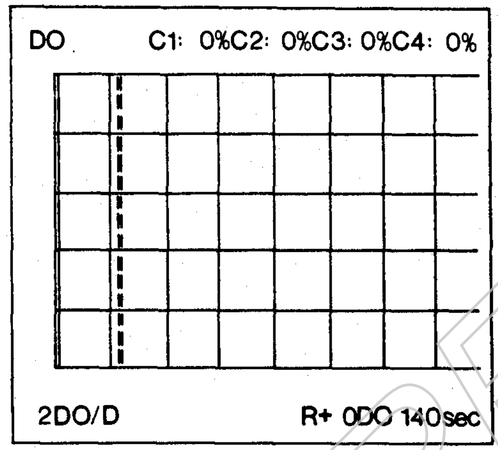


G. NOISE - Composite noise is indicated by the meter bars. The thin bar is used to mark which channel is being measured. To the left of the meter bars, the spectral noise is plotted.

H. FLUTTER - The bar on the right side is the percentage of composite flutter. The spectral flutter is on the frequency graph. The flutter reading above the graph is the 2 sigma value of the flutter.

Part of Figure 1.





I. SPEED - The ten second speed error from either 3 or 3.15 kHz is plotted on this graph. The I.S.E. reading is a one second average of the speed error.

J. DROP-OUT - The number of signal drop-outs for each 20 second interval is plotted in this test. C1, C2, C3, and C4 at the top are the drop-out annoyance categories. They are expressed as a percentage of the total number of samples.

FIGURE 1. Display graphs. The value of the vertical grid lines is shown along the bottom horizontal line and the horizontal line values are at the side of the graticules. These values do not appear on the actual display. Most of the displayed digital data has been eliminated for simplicity.

1. LEFT, RIGHT and L&R Switches: These switches determine the active channel for both the output and input terminals. The L&R switch will cause the same signal to appear at both left and right outputs. However, the measuring circuits at the input will only process or measure one channel at a time with the exception of the AZIMUTH test which is a phase comparison of both channels regardless of which channel is selected. In the NOISE test a marker indicates which channel is being measured and updated on the display. When the L&R switch is pressed in all test but AZIMUTH, the measurement is updated and displayed on the right channel first and then on the left. When either left or right channels are chosen, the opposite channel's output is terminated through the 1510A's output impedance except in the NOISE test where both outputs are terminated.

2. AC VOLTS Switch: When the AC VOLTS button is pressed, the 1510A is initialized to output a 1 kHz test signal at a level determined by the attenuator and/or to measure and display the level of the AC signal present at the 1510A inputs. These operations will not start until the START OUTPUTS and/or the START INPUTS buttons are pressed. In this mode, the 1510A inputs are a two channel DVM. The signals at the inputs are measured alternately and displayed as vertical bars with the value in volts and dBm. When the stop button is pressed, the test will stop and retain the last measurements displayed. The letters AC appear at the top left of the display.

3. INPUT REF SET/RECALL Switch: The 1510A requires a reference to determine the relative value of the measured data in the Distortion, MOL, Frequency Response and Noise tests. This reference is obtained by pressing the INPUT REF SET/RECALL button while the 1510A is in AC VOLTS and the desired reference value is being displayed. If in L & R, the right channel is used as the reference. A detailed theortical explanation is given in Section 2-14 and a procedure for the operation is given in Section 3-5. When the 1510A is in DISTORTION, MOL, FREQ RESP, or NOISE (Pre-Test or After-Test states) tests, the input reference level may be recalled by pressing the INPUT REF SET/RECALL button. The reference voltage appears momentarily in the lower left corner of the display replacing the scale factor.

4. AZIMUTH Switch: The phase differences between the right and left inputs are measured and displayed in this test. This phase error can be used to determine the azimuth error of a stereo or multi-track tape recorder. The Reproduce Alignment Test Tape (for playback head adjustment), and the special four-tone output of the 1510A (for record head adjustment) can be used to align the heads for correct azimuth. The usual noise and level variations of standard alignment tapes are not present when using this unique azimuth alignment procedure. Other azimuth test tapes can also be used if the frequencies are within the azimuth frequency windows. The 11.8 kHz window has been expanded to include all frequencies from 8 kHz to 13 kHz. This means that if a 10 kHz azimuth test tape is used, the phase error will be shown in the 11.8 kHz window. The letters AZ appear on the display.

NOTE: This test measures azimuth error in degrees of phase, not degrees of arc. In the Cassette format, for example, 10 degrees of error at 15 kHz is equal to less than .006 degrees of arc.

5. DISTORTION-2ND/3RD Switches: The distortion test function supplies a test frequency at 1/2 dB levels from +20 to -10 dB, relative to the preset 1500A output. The distortion test frequency is selected by pressing one of the DISTORTION FREQUENCY buttons prior to the start of the test. The recorder output level and harmonic distortion are measured by the 1510A. This data is displayed graphically as % harmonic distortion versus the recorder output level with one dB resolution.

Distortion on either or both channels can be displayed as required. The LSL button can be used to limit the lower levels of the sweep so that only the high levels of distortion are displayed. This will save time and eliminate data that may not be of interest. If a specific level is required to measure the distortion and to make some adjustments on the bias, the MANUAL MODE can be used. The output level can be changed with the cursor to the desired level. When in the MANUAL SWEEP MODE, the UP and DOWN switches act as a 1/2 dB OUTPUT LEVEL Vernier Control. A special feature has been added in the manual mode that allows the operator to get the exact 3% distortion level by using the output level verniers. The level reading in the lower-right corner of the display is the actual incoming level, measured to 0.1 dB. Get as close as possible to the 3% point with the cursor and then adjust the vernier to get exactly 3%. Remember to return the vernier to its previous setting before further testing. The D2 or D3 notation appears on the top left of the display. See Distortion Check Section 2-4.

6. FREQ RESP (Frequency Response) Switch: The 1510A supplies a stepped-frequency test signal from 40 kHz to 20 Hz (See page 28 for the frequencies used). The test signal level is controlled by the offset switches directly below the FREQ RESP switch. For example, if the -20 dB button is pressed, the test signal will be 20 dB below the preset 1510A output level. At the 1510A INPUT, the level and frequency are measured and graphically displayed as level versus frequency with the center vertical line on the displayed graph being the offset value. The frequency response of either or both channels can be displayed simultaneously. In the MANUAL MODE the output frequency is controlled by the position of the CURSOR on the display. So the output of the 1510A becomes a sine wave frequency generator. The INPUTS measure the frequency and the level of the incoming signal. This information is displayed on the CRT. See MANUAL switch, Section 1-4C, page 19, for more information. The letters FR are on the left top of the display. The NORM and FAST notations under the WEIGHTED and FLAT switches indicate a dual function. The FAST and NORM (Normal) apply to the rapidity that the output frequencies change when in the swept frequency response mode. When the FAST switch is depressed, the frequency response sweep time from 40 kHz to 1 kHz is about 1.8 times faster than the normal time. For 1 kHz to 20 Hz the FAST time is 1.25 times faster. the NORM mode is used when a slope of up to 60 dB/ octave is measured. The FAST mode response accuracy cannot be guaranteed for a slope of more than 30 dB/octave at frequencies above 1 kHz. When in the FREQ RESP test, the number of discrete frequencies output from the 1510A is twice the number of windows on the graph. This means that within each window there is a possibility that two frequencies will be measured, but only the last frequency successfully measured within the window will be displayed. This feature is valuable when measuring the frequency response of a tape recorder that has some time base jitter.

The required signal-to-noise ratio for successful frequency measurements is 20 dB. For a reasonably flat noise spectrum, the noise level will be about 6 dB higher than the composite level measured in the Noise-Flat test. This is because the noise bandwidth for frequency response is about 115 kHz and only 20 kHz for the Noise-Flat Test. Therefore if the composite noise level was -50 dB and the frequency response test was plotted at -20 dB from the reference, the signal-to-noise ratio would be 50 dB - (6 dB) - (20 dB) = 24 dB. Because of the 20 dB signal-to-noise requirement, the response can drop 4 dB before the noise interferes with the signal to prevent frequency data from being plotted. A coherency test in the 1510A will reduce the plotting of random noise when the signal-to-noise is less that 20 dB. Also note that low frequency bias signals or low performance bias traps in the recorder can further degrade the effective noise level. See Paragraph 1-3 and 2-3.

7. SPOT FREQ Switch: This test is the same as the regular Frequency Response test except that it skips groups of frequencies in its sweep. This gives the operator an over-all indication of the response of the device under test. The frequencies used are shown in the specifications on Page 4. When the Low Sweep Limit is used, it must be set at one of the indicated frequencies.

8. FD Switch: When both the 3RD DISTORTION and FREQ RESP switches are depressed simultaneously the 1510A will alternately perform two tests. The frequency sweep will go from 40 kHz to the LSL frequency in the normal way but at the end of each sweep a signal (the same as the 3rd or 2nd Harmonic Distortion frequency as chosen by the Distortion Frequency buttons when in the DISTORTION TEST, or 1000 Hz if the distortion test was not performed previously) is generated at the output at approximately the output reference level. The amount of 3rd Harmonic Distortion and the signal level are then displayed at the top of the display. In the MANUAL MODE, this test is not valid. Only REPEAT and SINGLE modes are active for this test. The letters FD are on the left of the display.

9. MOL (Maximum Output Level) switches: This test is activated when the SPEED and FLUTTER buttons are pressed simultaneously. The letters ML appear at the top left of the display. This test measures and displays the level of the input signal of a UUT (Unit Under Test) versus the output signal amplitude compression which goes to the input of the 1510A. In all other 1510A tests, the outputs and inputs are independent of each other. The MOL test is unique because the input as well as the output level of the UUT must be known in order to plot the MOL curve. Therefore, the START BOTH button should be used for this test. When this is done, the 1510A output utilizes the programmable attenuator to generate 1 dB steps at the 1510A outputs. These steps range from +20 dB above the output level to -10 dB below the output level. By utilizing the LSL button before starting the test, the sweep range can be reduced. The horizontal position of the cursor is indicated at the lower right hand side. This is the output level of the 1510A which is connected to the input of the UUT. The double vertical line is the 0 dB level. The cursor has dual function in the MOL Test. It not only selects and reads the output level of the 1510A but it also selects the test frequency. This frequency is shown at the top right side of the display after the letter C. As the position of the cursor is moved the frequency will also change. The frequency range is from 40 kHz to 40 Hz in approximately 1/3 octave steps. The exact frequencies are shown on page 27. The frequency that appears at the top right of the screen at the moment that the BOTH button is pressed is the one that will be used for the MOL test.

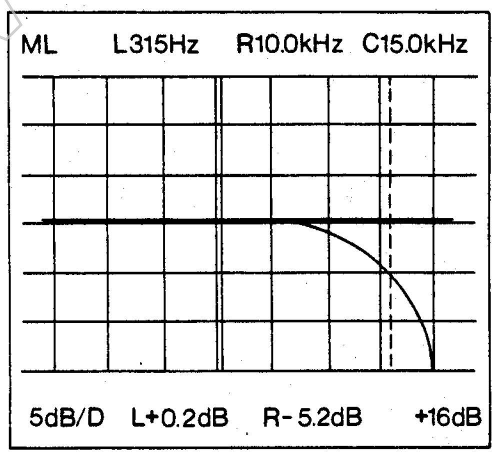


Figure 2. MOL Curves

Figure 2 is an example of the display after a MOL Test has been completed. The frequency of the test is indicated at the top center of the display. The signal amplitude compression is shown at the bottom center and the output of the 1510A is shown at the lower right hand corner of the display. The maximum output level is at the right side of the curve. See Paragraph 2-5.

10. CHAN SEP (Channel Separation) Switch: In this mode, the output (on the channel selected by the L or R buttons) is terminated through its output impedance. On the other channel there is a swept signal that starts at 20 kHz and goes to the LSL frequency. If the MANUAL button is active, a single frequency is generated as determined by the CURSOR. The display frequency resolution is 1/3 octave (See Para. 1-7 for frequencies); the offset buttons are active for this test also. At each frequency, the level of the input signal on each channel is measured. The ratio of the two levels is plotted on the display in a dB versus frequency graph. The letters CS are on the left top of the display. When the one-third Octave Spectrum Analyzer board is added to the 1510A, the signals for the channel separation test are passed through it to reduce the effects of noise on the readings. (See Para. 3-9 & 3-15C)

11. 75µS Switch: When FREQ RESP and SPOT FREQ are pressed simultaneously, a frequency response curve with a 75 micro-second time constant boost will be displayed. The +3 dB frequency is 2.122 kHz. This test is used when analyzing a phono cartridge in conjunction with the Sound Technology Test Record (TR150). When this test is activated, FS will appear on the top left of the display. See Turntable and cartridge testing, Section 3-14.

12. SPEED Switch: The 1510A can supply a crystal-controlled frequency (3.0 or 3.15 kHz as selected) to a high-quality tape recorder for making speed test tapes that can be used for testing recorders of lesser quality. Alternatively, with a speed test tape on a recorder, the 1510A will measure the absolute speed error (relative to tape accuracy) and display this graphically as speed error versus time. The Instantaneous Speed Error (ISE) is also shown in the upper right area of the screen, as a convenience for speed adjustments. The ISE measurement is the speed of the tape recorder measured for a period of one second. Even though the "Wow" of the tape recorder may effect the measurement, the ISE is useful for quick speed error indications. The letters SP will appear on the top left of the display. After displaying speed error against time, drift relative to any time point on the display can be measured by using the CURSOR switch and the VERT REF-DISPLAY button. Move the cursor to the point on the speed curve that is to be used as the reference. Press the VERT REF-DISPLAY button and move the cursor to the point on the curve you wish to compare to the reference speed. Read the drift directly on the display. The letters DR appear on the top left of the display when doing a drift measurement.

13. DROP-OUT Switch: The 1510A will detect drop-outs using one of the three standard selectable frequencies of 3 kHz, 3.15 kHz or 8 kHz. The test measures and plots dropouts vs. time from 20 seconds to 1000 seconds in 20 second intervals. The test not only counts the number of drop-outs in each 20 second interval but also categorizes them in accordance with IEC document #94, Sept. 1981. When the test completes its single sweep or is stopped, the categories are shown on the top line of the display. (See Para. 3-17.)

14. FLUTTER Switch: The 1510A supplies a crystal-controlled test frequency at either 3.0 or 3.15 kHz. At the INPUTS, flutter can be measured either FLAT or WEIGHTED, with the detection and meter dynamic characteristics in accordance with either NAB, JIS or DIN/ANSI specifications. Measurement standard details are given in Table 2 page 18. The meter bar shown on the display is also autoranged. A 2 sigma (95% of level) statistically averaged reading in percent is shown at the top of the display. The letters FL FT or FL WD are at the top of the display for the flat flutter or weighted flutter respectively. A note of caution is needed with this test. Unlike the other tests, the autoranging routine is not active during the test once the correct values are found and displayed.

If there is a need to autorange again, the operator must restart the autoranging by pushing the START INPUTS button. When the one-third octave spectrum analyzer is used, the display has an added frequency response graph showing three steps per octave from 200 Hz to 0.5 Hz. There is a digital frequency readout along with the level of the flutter spectrum readout in percent. The sweep time is about 280 seconds. The spectral response follows the FLAT and WEIGHTED buttons. The spectral FLAT response is flat to one dB from 200 Hz to 0.5 Hz and the WEIGHTED response is per the standard button that is depressed (See Table 2 and Section 2-10). The MANUAL mode allows the operator to measure the flutter at any one of the 1/3 octave frequencies.

15. <u>NOISE</u> Switch: The 1510A OUTPUTS are terminated through the output impedance. At the 1510A INPUTS, the noise level of either or both channels is measured and displayed as a bar graph. The scale is in dB, with 0 dB at the top and -100 dB at the bottom. The noise measurement is made relative to the input reference level. See INPUT REF SET/RECALL switch page 13. The measurement can be made either FLAT or WEIGHTED, with the detection and meter dynamic characteristics in accordance with NAB, ANSI, CCIR or CCIR/ARM standards. Measurement standards are given in Table 3 page 18. The letters NS FT or NS WD are at the top left of the display indicating flat noise or weighted noise respectively. When the one-third octave Spectrum Analyzer is added to the 1510A, the display will have a frequency response graph plotting three frequencies per octave from 20 kHz to 20 Hz. The frequency of the plot can be digitally read out using the cursor in the after-test state. The level (referred to the input reference level) is read out in dB. The response of the spectral noise when the FLAT button is depressed is not the same as the composite noise. The composite noise bandwidth is 20 kHz with the response down 3 dB at 20 kHz and 20 Hz. The spectral response is flat to within one dB from 20 kHz to 20 Hz. When the WEIGHTED button is pressed, the spectrum response is weighted per the standard button that is pressed. See Paragraph 3-15 for 1/3 octave option specifications.

16. <u>DATA STORAGE REVERSE</u> Switch: This is a memory switch. It allows the operator to compare data between two different parameters. The data acquired for any test is displayed as data received on the opposite input. This means that if the RIGHT button has been pressed, the incoming signal on the right channel will be plotted or measured as if the signal were on the left channel. This switch is a convenience for comparing two tapes, two adjustments, etc., while using the same recorder & 1510A electronics. When this switch is pressed the red light near the switch turns on. However, this button is active only during the active-test state. When the 1510A goes to the after-test state, the displayed data will be that for which the channel button has been selected. To make the data reappear on the display, go to the opposite channel or to L&R. This switch is not operational in the azimuth test.

17. <u>"OFFSET"</u> Switches: The four buttons located under the FREQ RESP and CHAN SEP switches are called OFFSET switches. They are used to command the microprocessor to offset the level of the output test signal and to change the value of the center horizontal display line when performing frequency response or channel separation tests. The center horizontal line is the same value as the OFFSET switch that is depressed. If for example the -10 dB OFFSET switch has been pressed, then the value of the data on the center horizontal line of the display is -10 dB. Refer to the FREQ RESP and CHAN SEP switches for more information on the OFFSET switches.

C. SWEEP MODE CONTROLS

The three sweep mode controls REPEAT, SINGLE and MANUAL and the OUTPUT MONITOR switch are mechanically interlocked.

Table 2. Flutter Measurement Standards

STANDARD	NAB	JIS	DIN/ANSI
Specifications	NAB E-416	JIS C5551	DIN 45 507, ANSI S4.3,
Detection	Full-Wave	Square-Law (RMS)	Peak-to-Peak
Meter Calibration	VU Meter	RMS	Peak
Meter Dynamics	VU Meter	Low Pass	Quasi-Peak
Weighted Response	Fig. 3	Fig. 3	Fig. 3
Flat Response	0.25 Hz to 200 Hz	0.63 Hz to 200 Hz	0.3 Hz to 200 Hz

Table 3. Noise Measurement Standards

STANDARD	NAB	ANSI	CCIR/ARM	CCIR
Specifications	NAB E-416	ANSI S 1.4	Dolby Labs S77	CCIR 468-2
Detection	Full-Wave	Square-Law (RMS)	Full-Wave Rectified Avg	Quasi-Peak
Meter Calibration	RMS	RMS	RMS	RMS
Meter Dynamics	VU Meter	VU Meter	VU Meter	CCIR 468-2 Para. 2
Weighted Response	"A" Curve Fig. 4	"A" Curve Fig. 4	Fig 5.	Fig 5.
Flat Response (-3 dB Frequency)	20 Hz to 20 kHz	20 Hz to 20 kHz	20 Hz to 20 kHz	20 Hz to 20 kHz

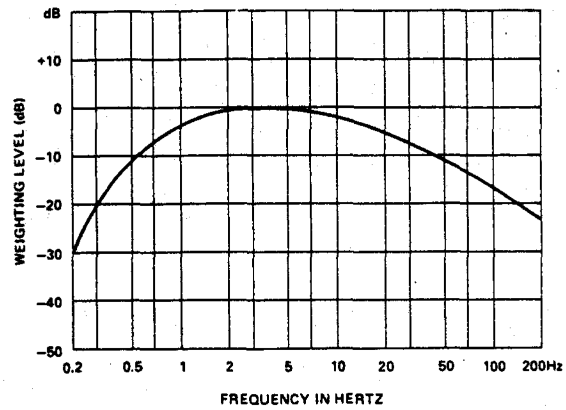


Figure 3. Flutter Weighted Frequency Response

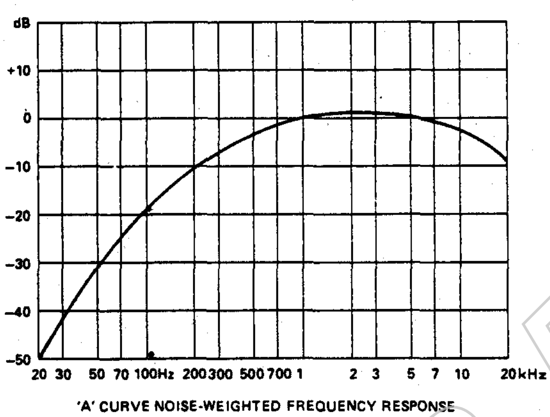


Figure 4. "A" Noise weighted Frequency Response

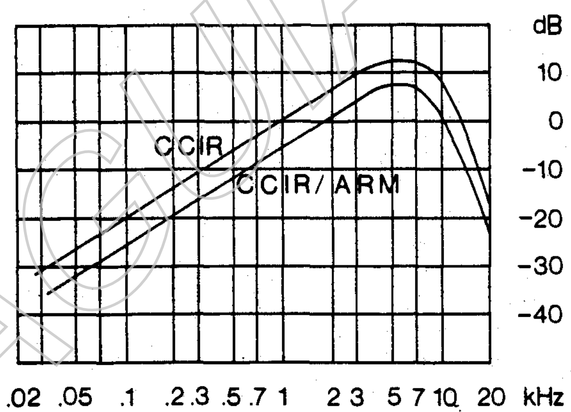


Figure 5. CCIR and CCIR/ARM Noise Weighted Frequency Reponses

1. MANUAL Switch: This mode provides a manual control of the output frequency for the frequency response and channel separation tests or the output level for distortion and MOL tests. The frequency or the level is indicated by the position of the CURSOR on the display. The output of the 1510A may not be the same value as the input due to a tape recorder or other device between the 1510A outputs and inputs. The difference can also be due to the more accurate measurement capability of the input side of the 1510A. For this reason, the cursor line on the display is not visable except during the time when the CURSOR switch is pressed. In the MANUAL mode, the incoming frequencies and levels are plotted as in the SINGLE and REPEAT sweep modes. The value of the data is shown as it is acquired in this mode.

2. SINGLE Switch: When using this sweep mode, during Distortion, MOL, Frequency Response, Channel Separation, Noise, Flutter, Drop-Out or Speed tests, the 1510A will execute one complete test sequence and then stop. The 1/3 octave option is required in order to have a sweep in the Noise and Flutter tests. If the 1510A is in START OUTPUTS but not START INPUTS the display will indicate "RECORD COMPLETED" at the end of the recorded test sequence. If in START INPUTS (or START INPUTS and START OUTPUTS), the 1510A will go to the After-Test state upon completion of one input test sequence.

3. REPEAT Switch: When using this sweep mode and in Distortion, MOL, Frequency Response or Channel Separation tests, the complete test sequence will be repeated until the STOP or SINGLE button is pressed. This statement is also true for NOISE and FLUTTER when the 1/3 octave option is installed. If the STOP button is pressed, the test stops immediately. The the SINGLE button is pressed, the test sequence in progress will be completed before going to the After Test state.

D. TEST COMMAND CONTROLS

The following controls start or stop routines.

1. START OUTPUTS/START INPUTS and START BOTH Switches: The 1510A output test signal is not present at the outputs until the START OUTPUTS button is pressed. This is to provide complete sequencing control when testing recorders. Similarly, the 1510A does not start to measure input signals and display the results until the START INPUTS button is pressed. Otherwise, there would be many instances of extraneous and confusing data appearing on the display. For convenience, a START BOTH button is provided, which starts both inputs and outputs.

2. STOP Switch: Pressing the STOP button causes the 1510A to immediately terminate any test and go to the After-Test state. It has no effect when the 1510A is in the Self Check or Output Monitor states.

3. OUTPUT MONITOR Switch: Pressing this button forces the 1510A to the OUTPUT MONITOR state. In this state, the outputs are automatically started, the inputs are connected to the outputs, and the level(s) are measured and displayed using the AC Volts display format. The OUTPUT MONITOR state is provided so that the actual test levels at the 1510A outputs, with recorder connected and operating, can be verified. For tests that are made verses frequency or level, the mid-band test values are selected for the OUTPUT MONITOR as specified in Table 4. For the SPEED and FLUTTER tests, the output frequency depends upon which standard has been chosen. These standards are NAB, JIS and DIN/ANSI. In NOISE, the output is terminated by the output impedance.

E. MISCELLANEOUS

1. SELF CHECK Switch: Pressing the SELF CHECK button moves the 1510A to the Self Check state. This check is an operational test of most circuits in the 1510A. The CRT screen will read "TESTING" while the tests are in progress and "I AM OK, YOU ARE OK" at the successful completion of the test. If the test does not successfully complete, various messages will be displayed that aid in locating the problem area. See Paragraph 1-6B for Failure Mode messages. If the problem is found, attempts at repair by the user are not recommended as special facilities and equipment are required. Refer to the MAINTENANCE section for more details. Only the reset button will make the Self Check routine stop and return to AC VOLTS.

2. RESET Switch: It is possible, as with any microprocessor-controlled instrument, that some sequence of control actuations or transient conditions exist that could force the instrument into an undesired or unrecognized mode of operation. Any such condition can be cleared by pressing the RESET button which will reinitialize the 1510A to the Pre-Test state and then automatically place the 1510A into the AC Volts mode. Another function of the RESET button is to move the 1510A from the Self Check state. The 1510A will remain in the Self Check State until the RESET button is pressed.

3. SPEAKER Control: Via a built-in speaker, a test signal or voice announcement in the 300 Hz to 8000 Hz range at the selected 1510A input can be monitored. The control adjusts the speaker volume.

4. OUTPUT LEVEL Controls: The level of the outputs is controlled by the 0.1 dB vernier and the -20 dB and -40 dB buttons. The level may be changed at any time except during Self Check, when none of the buttons are operative except RESET. When the 1510A is powered-up, the output level is automatically set at +4.0 dBm. To reduce the output level by 20 dB or 40 dB, press the -20 dB or -40 dB buttons, respectively. To reduce the level by 60 dB, press both buttons in.

The vernier has a 20 dB range. When either the UP or DOWN button is pressed in and held, the level will change 0.1 dB and hold at that level for one second. After one second, the level changes several more times in 0.1 dB steps and then changes in 1.0 dB steps until the attenuator's range is covered. Single steps of 0.1 dB may be obtained by quickly pressing and releasing the button.

Table 4

TEST	MID-BAND VALUE
AC Volts	1 kHz
Azimuth	2.8 kHz, -20 dB
Distortion	0 dB Level (selected frequency)
Frequency Response	1.0 kHz (selected offset)
Channel Separation	1.0 kHz (selected offset)
MOL	315 Hz, 0 dB
Speed	0 dB, (selected frequency)
Drop Out	-20 dB level (selected frequency)
Flutter	0 dB level (selected frequency)
Noise	Outputs terminated into 50 ohms

1-5 REAR PANEL CONNECTORS

A. AC Power Input, Fuse, Voltage Select Connector: This multi-purpose device is located at the lower right side of the rear panel. When the power cord supplied with the 1510A is inserted in the connector, a sliding plastic cover will protect the fuse and the voltage changing section of the connector. If the power cord is removed, the plastic cover can be moved to expose the fuse. TO CHANGE THE FUSE OR INPUT VOLTAGE: Lift up on the handle labeled "FUSE PULL" to release the fuse. Insert a new fuse (1.5A, 250 V, slo-blo), or to change the voltage select PC board: use a small hook or wire to slowly pull out the small PC board located just under the fuse. Note as the PC board is being removed that one of the voltages etched on the board (100, 120, 220, 240) is visible and "right side up" (the same way as "Fuse Pull"). Turn the PC Board and reinsert it so the operating line voltage is visible in exactly the same manner as when the board was first removed from the connector. When the board is fully inserted, replace the fuse and slide the plastic cover back over the fuse section. Replace the line cord.

B. VIDEO OUT Connector: A large screen black and white video monitor can be connected to the 1510A for remote or detailed viewing of all data that appears on the 1510A display. Signal level is 2 V p-p, negative horizontal sync, industrial, composite video, 2% overscan with 75 ohms output impedence.

C. SIGNAL OUT Connector: Provides a ranged and processed signal representative of the input as selected by a test button. The more useful signals are detailed in Table 5.

NOTE:
If the L&R button is pressed, some of these signals will be alternately obtained from the two input channels. These signals are useful for spectrum analyzer monitoring, but are not intended to be used for automatic absolute level measurements, since no ranging information is supplied.

Table 5.

TEST	AUTORANGED SIGNAL AT "SIGNAL OUT" BNC
AC Volts	10 Hz to 98 kHz bandwidth
Distortion	Test signal, 20 Hz to 20 kHz bandwidth
Frequency Response	Test signal, 10 Hz to 98 kHz bandwidth
Flutter	Demodulated, "FLAT" of "WEIGHTED" flutter
Noise	"FLAT" or "WEIGHTED" noise
Drop-Out	Test signal
Speed	Test signal
Azimuth	Test Signal
MOL	Test Signal
Channel Separation	Test Signal, 20 to 20 kHz bandwidth

D. IEEE 488 CONNECTOR AND ADDRESS Switch: This is an optional connector and switch used to connect the 1510A to the General Purpose Interface Bus (GPIB) as defined in the IEEE-488 Standard. See the 1510A GPIB (General Purpose Interface Bus), option 009, paragraph 3-16, page 57.

1-6 DISPLAY MESSAGES, SYMBOLS & STATEMENTS

The following section will define and explain the various notations on the CRT display.

A. ERROR CODES

ERROR CODE 00 — The microprocessor cannot properly write 1024 bytes of software into the RAM and then read it back for comparison.

ERROR CODE 0E — The microprocessor cannot communicate properly with the interface board.

ERROR CODE 0F — The microprocessor cannot communicate properly with the front panel board.

B. FAILURE MODES

When the 1510A is in the SELF CHECK mode, the following messages can appear on the display. Refer to Paragraph 4-2 for help when these FAILURE MODE messages appear.

TESTING — The 1510A is in the SELF CHECK Mode.

OUTPUTS AT 2.0 VOLTS?

When any of the tests in SELF CHECK do not pass, the failure mode letter and the question "OUTPUTS AT 2.0 VOLTS?" appear on the screen. This is a reminder to adjust the output signal level to 2.0 volts before starting SELF CHECK. The 2.0 volts should be set in FREQ. RESP. with the OUTPUT MONITOR button pressed.

FAILURE MODE	CIRCUITS TESTED
ALL MODES	Microprocessor board; Interface board; sweep oscillator; programmed attenuator; front panel level controls; output amplifier; left monitor amplifier; A. C. ranging amplifier.
A	"A" weighting filter, quasi-peak circuit, statistical filter, D.C. Amps.
B	CCIR noise filter; RMS circuits & VU dynamics
C	Noise flat filter, fullwave circuits
D	300 Hz filter
E	Sweep oscillator, ranging D.C. amplifier
F	Programmed attenuator
G	JIS filter
H	Ranging amplifiers and azimuth circuits
I	Speed test and drop-out detector
J	1 kHz discriminator
K	1 kHz discriminator
L	Speed test and drop-out detector
M	Flat flutter circuits and peak detector
N	"A" weighted flutter filter
O	2nd harmonic distortion circuits, distortion ranging amplifiers, and D.C. ranging amplifiers
P	3rd harmonic distortion circuits
R,S,T,U	Third octave filter circuits at 1 kHz, 63 Hz, 20 Hz and 20 kHz respectively
V	Third octave filter ranging amplifier and RMS circuits
W	Third octave filter ranging amplifier

X	GPIB Circuits

C. TEST SYMBOLS

These symbols appear at the top left of the screen and indicate which test button has been pushed.

SYMBOLS	TEST
AC	AC Volts
AZ	Azimuth
CS	Channel Separation
D2	2nd Harmonic Distortion
D3	3rd Harmonic Distortion
DO	Drop-Out
DR	Drift
FD	Frequency response and 3rd harmonic combination test.
FL	Flutter
FR	Frequency Response
FS	75μ Second
FT	Flat response for flutter or noise tests, or Spot Freq.
ML	MOL (Maximum Output Level)
NS	Noise
SP	Speed
WD	Weighted response for flutter or noise tests

D. CHANNEL INDICATORS

L	Left button pressed
R	Right button pressed
LNO DATA	No data on the left channel
RNO DATA	No data on the right channel
R>L	Channel separation, right channel driven
L>R	Channel separation, left channel driven

L XXX V	The left channel has XXX volts at the left input connector.
R XXX V	The right channel has XXX volts at the right input connector.

E. MODE SYMBOLS

OM	Output monitor button
O	Start outputs
I	Start inputs
I AND O NOT VALID	This test will not work if both the Input and Output buttons have been pressed.
START INPUTS AND OUTPUTS TOGETHER.	Use the START BOTH button.

F. REFERENCE NOTATIONS

REF NONE	No reference level has been placed into the memory. This must be done when in AC VOLTS and the INPUT REF SET/RECALL button is pressed.
REF XXX dBm	The reference in the 1510A memory is XXX dBm. The noise, frequency response, MOL and distortion tests must have a reference.
NO REFERENCE	When the noise, freq resp, MOL, or distortion test buttons have been pressed and no reference has been placed into the 1510A memory, this message will appear on the screen.

G. OTHER MESSAGES

FS 1.00 V	The bar graph full scale reading is one volt.
10 dB/D	This can appear in two places on the display: (1) at the top of the bar graph where it indicates that each horizontal division of the graph is 10 dB; (2) at the bottom left, where it indicates the number of dB per horizontal line of the graph.
FS 3.0%	The bar graph full scale reading is 3%.
.010%/D	Each horizontal line represents a .010% change.
60 DEG/D	Each horizontal line indicates a change of 60 degrees.
TERMINATED	The output is terminated by its output impedance.
L.S.L.	The LOW SWEEP LIMIT. It is the frequency or level that will cause the test to stop or repeat.

MANUAL SWEEP NOT VALID	This test will not work in this mode. Another one of the SWEEP MODE switches must be pressed.
REPEAT SWEEP NOT VALID	This test will not work in this mode. The SINGLE SWEEP button must be pressed.
TEST f=3 kHz	In the Speed tests the frequency which the test is set up for is 3 kHz.
TEST f=3.15 kHz	This may be changed to 3.15 kHz by pressing the 3.15 button.
SIGNAL TOO HIGH	The signal level into the 1510A INPUTS is more than 40 V RMS. In the distortion and flutter tests, the input signal may be less than 40 V RMS but the flutter or distortion levels are too high. The maximum levels are 10% for both flutter and distortion tests.
SIGNAL TOO LOW	The signal level is too low for the 1510A to measure. The signal level into the 1510A may be a high enough level but the filter used in weighting the signal may result in a level too low. This can happen in noise, flutter or distortion tests.
CREST FACTOR TOO HIGH	Crest factor is the ratio of the signal's peak value to the RMS value.
REMAINING TIME: XXX SECONDS	The time that is remaining before the output stops in the Speed test.
R REF	The phase is measured with respect to the right channel.
OS	Indicates the state of the offset buttons.
C1, C2, C3, & C4	Indicate the IEC drop-out categories.
RECORD COMPLETED	The test sequence for recording a tape is finished.

1-7 OUTPUT FREQUENCIES USED IN VARIOUS TESTS

Test	Frequencies
A.C. Volts	1000 Hz ± 2%
Azimuth:	2.8, 5.7, and 15.8 kHz ± 1 kHz Minimum 11.8 kHz +1/-4 kHz Minimum
Distortion:	315, 333, 400, or 1000 Hz ± 1%
Flutter & Speed:	3.00 or 3.15 kHz ± .005%
Drop Out:	3.0, 3.15, or 8.0 kHz ±5%
Spot Frequency:	20, 50, 100, 200, 500, 1 k, 2 k, 5 k, 10 k to 20 k, 40 kHz ±3%

Channel Separation:
(3% Tolerance)

Hz	Hz	kHz	kHz
	100	1.00	10.0
	125	1.25	12.5
	160	1.60	16.0
20.0	200	2.00	20.0
25.0	250	2.50	
31.5	315	3.15	
40.0	400	4.00	
50.0	500	5.00	
63.0	630	6.30	
80.0	800	8.00	

MOL:
(3% Tolerance)

Hz	Corresponding Levels (in dB)
40.0	-10
50.0	- 9
60.0	- 8
80.0	- 7
100	- 6
125	- 5
150	- 4
200	- 3
315	- 2
333	- 1
400	0
500	+ 1
600	+ 2
800	+ 3
1.00k	+ 4
1.25k	+ 5
1.50k	+ 6
2.00k	+ 7
3.15k	+ 8
3.33k	+ 9
4.00k	+10
5.00k	+11
6.00k	+12
8.00k	+13
10.0k	+14
12.5k	+15
15.0k	+16
20.0k	+17
31.5k	+18
33.3k	+19
40.0k	+20

Frequency Response:
(3% Tolerance)

Hz	Hz	kHz	kHz
	100	1.00	10.0
	105	1.05	10.5
	115	1.15	11.5
	120	1.20	12.0
	130	1.30	13.0
	135	1.35	13.5
	145	1.45	14.5
	155	1.55	15.5
	165	1.65	16.5
	175	1.75	17.5
	185	1.85	18.5
20	200	2.00	20.0
21	210	2.10	21.0
22	220	2.20	22.0
24	240	2.40	24.0
25	250	2.50	25.0
27	270	2.70	27.0
29	290	2.90	29.0
31	310	3.10	31.0
33	330	3.30	33.0
35	350	3.50	35.0
37	370	3.70	37.0
40	400	4.00	40.0
42	420	4.20	
45	450	4.50	
47	470	4.70	
50	500	5.00	
54	540	5.40	
57	570	5.70	
60	600	6.00	
65	650	6.50	
69	690	6.90	
73	730	7.30	
78	780	7.80	
83	830	8.30	
88	880	8.80	
94	940	9.40	

Flutter:

Hz	Hz	Hz	Hz
	1.00	10.0	100
	1.25	12.5	125
	1.60	16.0	160
	2.00	20.0	200
	2.50	25.0	
	3.15	31.5	
	4.00	40.0	
0.500	5.00	50.0	
0.630	6.30	63.0	
0.800	8.00	80.0	

SECTION 2

OPERATOR FAMILIARIZATION
AND
ADDITIONAL TEST INFORMATION

2-1 GENERAL

This section of the manual is designed to give a new operator basic familiarity with the 1510A operation and to discuss the various tests. Many of the procedures outlined here do not require a tape recorder. In many cases, the output signals are routed directly back to the input to provide signals for measurement and display. The steps should be followed in the order given, as many of them are sequence-dependent. Please note that the switches and push buttons are in capital letters. Also when START INPUTS and START OUTPUTS are needed, which means START BOTH, the letters SIO are used in this manual, and the LOW SWEEP LIMIT button is called LSL.

2-2 INITIAL SETUP

Connect a jumper cable between the OUTPUT LEFT and INPUT LEFT connectors. Repeat for OUTPUT RIGHT and INPUT RIGHT connectors.

See that the following push-on/push-off buttons are released (button out position): EXPAND, SPLIT, -20 dB, -40 dB, and DATA STORAGE REVERSE.

Press: LEFT

Turn POWER SWITCH on. After a short warm-up of the CRT the display will show: "AC REF NONE". Press OUTPUT MONITOR then the display will show "AC OM REF NONE". Adjust vernier up until display shows "L 2.00 V" (±.05 V) at bottom of screen.

Press SELF CHECK button. Screen shows "TESTING". Turn SPEAKER control up from the CCW (counter clockwise) position. The self check test signals can be heard. After the test is complete, the display shows "I AM OK, YOU ARE OK". If a fault is indicated on the display refer to the MAINTENANCE section and paragraph 1-6B.

Press RESET button. Adjust vernier down until display shows approximately "L 1.00 V" at bottom of screen. Press SELF CHECK button. Display will soon show "FAILURE MODE A, OUTPUTS AT 2.0 VOLTS"? This shows that the output must be set to 2.0 ± .05 volts for SELF CHECK to pass.

Press: RESET, SINGLE or REPEAT, START INPUTS. The 1510A is now measuring and displaying the wide-band residual noise on the LEFT channel. An "I" appears in the upper left corner of the screen. This indicates that the 1510A input circuits are active, measuring and displaying the signal (presently noise) on the 1510A input.

Press START OUTPUTS. "OI" appears in the upper left. The 1510A output circuits and input circuits are now active. Move vernier down. Note that the voltage and dBm readings, bar graph value, and meter full-scale value ("FS") all change as required. Set vernier for a level of "1.00 V +2.2 dBm".

Press INPUT REF SET/RECALL button. Screen shows "OI" (Output, Input), "REF +2.2 dBm" (Input reference level +2.2 dBm). An input reference level of +2.2 dBm has been put into the 1510A digital memory, and will subsequently be used when doing distortion, frequency response, MOL, and noise tests. This operation is explained in detail in paragraph 2-14 and 3-5.

2-3 FREQUENCY RESPONSE CHECK

Press: L&R, FREQ RESP, -10 dB (offset), and REPEAT buttons. The display will show a graph with a dotted vertical line (cursor position) at the center of the display with the legend: "FR" (Frequency Response) OS: -10 dB" (offset: -10 dB) "LSL 20 Hz" (low sweep limit of 20 Hz). The legend below the graticule shows "10 dB/D" (vertical scale factor: 10 dB per division) "1.00 kHz" (cursor frequency setting).

Press: INPUT REF SET/RECALL. Note that the input reference value momentarily appears in the lower left corner of the screen.

Move the CURSOR POSITION switch momentarily to the right and release it. Note cursor movement. Repeat this procedure several times, holding switch to right or left for successively longer periods. The switch action allows incrementing cursor a step at a time, or if the switch is held in one position, the cursor movement speeds up to span the entire screen in a few seconds. Cursor frequency is displayed in the lower right corner of the screen and is updated as the cursor position changes.

Stop the cursor at any frequency. Press LOW SWEEP LIMIT SET button. "LSL" legend above the graticule will change to match cursor frequency. Repeat with cursor at other frequency settings.

Set cursor to 20 Hz position. Press LOW SWEEP LIMIT SET button and the NORM switch.

Press START INPUTS button. Display shows the letter "I" in upper left corner, indicating 1510A input circuits are measuring the input signals. "10 dB/D" remains on screen to show the vertical scale factor.

Press START OUTPUTS button, letter "O" appears in the upper left corner of the screen indicating 1510A is putting out a test signal. A trace will begin to appear at the right side of the display. (If the SPEAKER control is turned from the full CCW position, the speaker in the 1510A can be heard.) The trace will become a line extending from the right of the display as the frequency response of the 1510A is checked. The construction of the trace slows as successively lower frequencies are reached.

Immediately after the first trace is completed (showing the response of the right channel), a second trace begins to show the left channel response. As long as the 1510A remains in the REPEAT mode, the traces will be updated (redrawn) alternately until either the STOP button is pressed, stopping trace construction immediately, or the SINGLE button is pressed, which will stop trace construction at the end of the complete sweep. The spot that is blinking on the display indicates the data point that has just been updated. As soon as the trace is stopped or completed, the legend "OI" disappears from the top left of the screen. Levels of each trace relative to the input reference level at any selected cursor frequency appear on the screen if data was obtained at that frequency.

Press the SPLIT button. The traces will separate into two distinct lines (right channel response on top, left below). If the EXPAND button is pressed, the vertical scale factor changes to 2 dB per division, allowing examination of trace detail. Traces may be moved up or down on the display by pressing the VERTICAL DISPLAY, UP, or DOWN buttons repeatedly. NOTE: If the traces cannot be seen, but the top grid line (for example) seems particularly bright, the traces are above the top of the display area. Press the DOWN button repeatedly until the trace is visible. Remove the EXPAND button from the depressed position before pressing the DOWN button to reduce the number of times the DOWN button must be pressed to see the trace.

NOTE: Pressing any of the VERTICAL DISPLAY buttons does not change the data read by the cursor.

While each trace is normally shown referenced to the input reference level, if the DISPLAY button is pressed, the level at the cursor is redefined as "0 dB". For example: Press: LEFT and EXPAND, release SPLIT. The left channel is now displayed near the center horizontal grid line. Move the cursor to a frequency that displays a level not on the center horizontal grid line (not

-10 dB), then press the VERT REF, DISPLAY button. The trace moves up or down to position the level at the center line on the display. The level at the cursor now reads: "0 dB," with the trace retaining its original shape. Moving the cursor will show levels relative to this new 0 dB reference. This feature is useful in finding the half-power (-3 dB) points, or the maximum level deviation from a reference other than Preset Input Reference. Press: VERT REF, INPUT REF. Notice that the original data is now displayed.

Press RIGHT. The left channel data is removed and the right channel data is recalled for display.

Press the FAST switch and move the CURSOR to 1.00 kHz. Press the LSL switch and "L.S.L. 1.00 kHz" will appear at the top of the display. Go to SINGLE and START INPUTS and OUTPUTS. A trace will begin at the right side of the display as before but it will sweep about twice as fast. The MANUAL mode is a very interesting feature of the 1510A. For example, press the MANUAL button and SIO. Move the CURSOR to about 1 kHz and turn up the speaker volume so that it is audible. Notice the legend on the top right of the display that reads VERNIER. The arrow to the right points to the UP and DOWN buttons which can be used to raise or lower the frequency of the output signal. The amount that the frequency can be changed is about 3%. Press the SPOT FREQ button. Note the letters "FT" in the upper-left corner of the CRT. Set the L.S.L. at 20 Hz and press SINGLE, START BOTH. Note that the sweep is a broken line with segments appearing at specific frequencies, as listed in Paragraph 1-7. These segments overlap the specific frequencies in order to assure that each specified frequency is plotted. In order to function properly, the L.S.L. must be set at one of the specified frequencies in Paragraph 1-7. This test sweeps about 65% faster than the full sweep test and is used to get a general picture of the device's frequency response. It can also be used in quality assurance tests. Except for the manual mode, which is not valid, all the buttons and switches that apply to the regular frequency response test apply to this one also.

2-4 DISTORTION CHECK

Press: LEFT, DISTORTION 2ND, SINGLE, 1000 Hz Distortion Frequency, START INPUTS. Release SPLIT and EXPAND buttons if pressed. The legend "D2" will appear in the upper left corner of the display.

Press: START OUTPUTS. A trace will begin to appear at the right side of the display along the bottom horizontal grid line. When the trace is completed the cursor will appear on the display. Use the UP button as necessary to position the trace within the display area. Distortion is displayed both in percent at the top of the display (e.g. L 0.02%), and in dB at the bottom (e.g. L-74.1 dB). The distortion values are measured at the input test signal level as indicated by the cursor (shown at the lower right of the display). The test signal level extends from approximately +20 to -10 dB referred to the input reference level. In many applications, the distortion of a signal below the reference level is of little interest. Therefore, by utilizing the LSL, the distortion test can be made to go only to the level of interest. This will save time and eliminate extraneous data.

Note that the trace is made up of a number of discrete level steps along the horizontal axis, each step representing one dB the input signal's level, relative to the input reference level.

If the cursor is incremented one or more steps to the right of the displayed trace steps, the notation LNO DATA and/or RNO DATA appears on the display, indicating no data at that test level. The same occurs if the cursor is positioned to the left of the trace steps.

Repeat the above tests by observing both the left and right channels by pressing L&R, SINGLE. Move the cursor to the 0 dB position (the double line) and press the LSL button, START INPUTS, and START OUTPUTS. When the traces are completed, use the UP, SPLIT, and EXPAND buttons as required.

The manual mode is also effective for distortion testing with the UP and DOWN buttons changing the output level by 1/2 dB steps. Put the 1510A into the MANUAL mode and SIO. Push the UP and/or DOWN buttons. Observe that the input level changes.

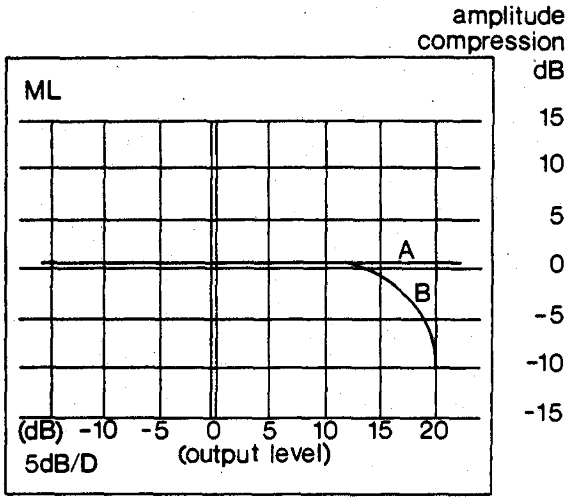
2-5 MOL (MAXIMUM OUTPUT LEVEL) CHECK

Press the two buttons over MOL (SPEED and FLUTTER) at the same time. The letter ML will appear at the top left of the display. The LSL value for MOL will be at the top center of the screen. The frequency of the output signal will be indicated by C4.00 kHz on the screen and the level of the 1510A output signal is shown at the lower right hand corner. Move the cursor to the left so that the output is -5 dB (reading at botton left). Press the LSL button and see that the LSL reading has changed to L.S.L. -5 dB. Move the cursor so that the frequency changes from C1.25 kHz to 10 kHz. Press: L&R, SINGLE. Press: START BOTH. Two curves will be plotted on top of each other with both stopping at -5 dB. The frequencies of each plot are indicated on the top line of the display. The level of the graph where the cursor is located is on the botton line of the display. If the cursor is moved to the left and stopped when the reading on the far right is changed from +4 dB to 0 dB, the L and R readings will be 0 dB $\pm$ .1 dB. When the output and the input levels are the same, the curve will be a flat, horizontal line. If the tests were done using a tape recorder, the output may not be a horizontal line at the higher levels when high frequencies are used because of tape saturation. As the distortion of the signal increases, the plotted curve will no longer be a straight line. If two curves are made, one at some low frequency, say 400 Hz, and the other at 10 kHz, the curves will be coincident if the frequency response is flat between these two frequencies at all levels. The curves will appear as in Figure 6A. These curves will become parallel lines if the response is not flat as in Figure 6B. As shown in Figure 6C, curve C goes into saturation at the higher levels.

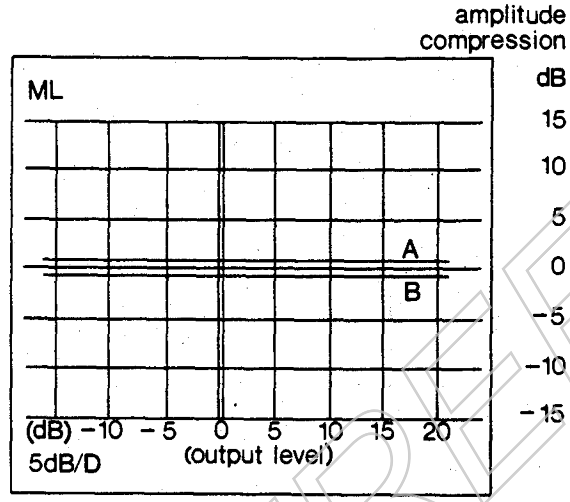
If as in Figure 6C, the point at which the curve begins to saturate is desired, you simply move the cursor and read the amount of amplitude compression at the bottom center of the display. First, the lower level where the plot is flat must be referenced to 0 dB. Move the cursor to the lower flat level and press VERT REF - Display button. This will force the curve to be referenced at 0 dB compression and the measurements can then be made.

2-6 FREQUENCY RESPONSE with 3RD DISTORTION CHECK

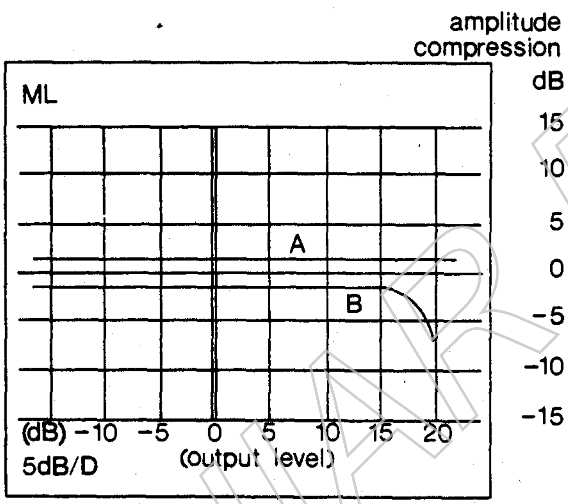
This combination test can be implemented by pressing simultaneously the FREQ RESP and 3RD DISTORTION buttons. The letters FD appear at the top left of the screen. Set the LSL to any frequency by moving the cursor to the the lowest frequency of interest and pressing the LOW SWEEP LIMIT button. The frequency of the distortion test will be 1000 HZ as chosen in the DISTORTION test. This can be changed by first pressing the DISTORTION 3rd or 2nd button and then pressing the desired DISTORTION FREQUENCY button. Then return to this test and Press BOTH. The frequency is swept from 40 kHz to the LSL frequency. After the sweep, a signal is generated at the selected distortion frequency and measured for level and 3rd harmonic distortion content. This measurement is displayed at the top of the screen. If a tape recorder were tested, a typical legend would be "R0.40%, +0.2 dB". In the typical tape recorder reading, the legend means that on the right channel the 3rd harmonic distortion is 0.4% when the signal level is at +0.2 dB from the reference level. However, by testing the 1510A output signal directly, the notation will be "R HD3 TOO LOW".



A. Coincident curves from an input level of -10 dB to + 10 dB. Curve B begins to saturate at levels higher than 10 dB. Curve A is linear from -10 dB to +20 dB.



B. Parallel curves caused by different levels between inputs. They can also be caused by differing frequency responses.



C. These two curves have different frequency responses or levels with Curve B saturating at higher levels.

Figure 6. MOL Curves

2-7 AZIMUTH CHECK

This test is best illustrated by putting a BNC "T" connector on the left output and connecting a cable from one side of the "T" to the left input. Connect a BNC- to-clip-lead cable to the other side of the BNC "T" and connect a 0.1μF capacitor between the two clip leads. Press the AZIMUTH button and BOTH. Four small bars will be present on the display. Stop the test and move the cursor to the 15.8 kHz bar. Note that the value of the phase difference between the RIGHT channel and the LEFT channel is on the bottom center of the display. It should read approximately "+24 DEG 15.8 kHz". Now move the cursor left to the next bar and read "+17 DEG 11.8 kHz" and so forth. The capacitor produced a delay in the left signal and the azimuth test has read the phase difference between the two inputs at four different frequencies. Remove the capacitor and BNC-to-clip-lead from the BNC "T".

2-8 DROP-OUT TEST

This test counts drop-outs and displays them in 20 second intervals. It also categorizes them into the I.E.C. #94 drop-out categories. These categories are based on depth, duration and sequence of the drop-outs. The four I.E.C. categories are displayed on the top line of the CRT when the test finishes after 1,000 seconds or the STOP button is pressed. The graphical data is simply drop-outs per 20 seconds, a drop-out is defined in Paragraph 3-17, Page 70. To get an idea of how the test works, connect the left output to the left input. Be sure the -20dB and -40dB buttons are both out. Press: LEFT, SINGLE, DROPOUT (FLUTTER & NOISE), START BOTH. To generate some false drop-outs, quickly press and release the -20dB output button. When the graphical data is above the bottom line of the graticule, press STOP. Observe with the cursor the number of drop-outs and observe the categories on the top line. (See page 70 for more information on Test.)

2-9 SPEED CHECK

This test cannot be done unless there is an external generator connected to one of the input channels. If this is done and the correct channel is selected, the 1510A will measure the frequency difference between the external generator and the internal clock of the 1510A. The frequency of the clock is determined by the standard button depressed. If 3 kHz is chosen, then the button above the 3.0 notation is pressed (the same as the NAB or JIS Flutter buttons). The legend I.S.E. on the top of the display is used to give a quick indication of the speed error. If the error is more than 4% low, then the I.S.E. and the graph will display the notation <-4.00% and no plots will be made in the display until STOP is pressed. The graph will change much slower than the I.S.E. because there is a 10:1 ratio in time between these readings. To determine the drift of the signal, stop the 1510A after it has had time to plot a line segment. Move the cursor to one end of the speed curve and press VERT REF-DISPLAY button. Then move the cursor to the other end of the curve and read the speed error. The displayed percentage is the amount that the external generator has drifted during the test.

2-10 FLUTTER CHECK

Normally in this test you are looking for the flutter of a tape recorder playing a pre-recorded test tape. In doing so you must decide what flutter standard you will use and if the flutter measurement is to be flat or weighted. Once this is decided and the test signal is present at the input to the 1510A, then press START INPUTS. When this is done, the top of the screen will read "FL I WD R" if the right channel is selected. After about 13 seconds a bar and the 2-sigma reading will appear on the top of the screen. If "SIGNAL TOO HIGH" or "SIGNAL TOO LOW" appears on the screen, wait to see if the error messages are removed and the test continues after a few seconds. These messages may be caused by a signal transient from the recorder when the test is started.

The 2 Sigma reading is defined as the following: If flutter is sufficiently random, then the amplitude of the flutter signal can be described by a Gausian amplitude distribution bell curve. Using the probability scale of this curve, the probability that the amplitude will exceed the 2 Sigma axis during a given time is 4.5%. It has been shown that a meter read by a very skilled operator who takes into account the characteristics of the flutter signal will come very near to the 2 Sigma reading.

The 1/3 octave option expands the flutter test to a flutter spectral test. The flutter bandwidth from 200 Hz to 0.5 Hz is displayed in 1/3 octave frequencies. (See Para. 1-7 for displayed frequencies. Refer to the channel separation frequencies and divide each by 100 for the flutter frequencies.) There is no easy way to look at this test unless a tape recorder with a flutter test tape is played back into the 1510A and the spectral displays are observed.

2-11 CHANNEL SEPARATION CHECK

Connect the cables between the 1510A outputs and inputs. Press: CHAN SEP, 0 dB offset, RIGHT, SINGLE. Set LSL to 1 kHz. A sweep from 20 kHz to 1 kHz will be plotted on the bottom line. When the test is completed, the cursor will appear on the display. If "CREST FACTOR TOO HIGH" is flashed on the display, then stop the test when the "0" disappears from the screen at the top left corner. Push the UP button until the total curve is visible. This is a plot of the residual channel separation of the 1510A from the generator to the measuring circuits. If the 1/3 octave board is in the 1510A, then the signals on the channel being tested, in this case the right channel, go through the 1/3 octave filters before they are measured. This board reduces the noise that is present at each frequency being measured and is an invaluable asset in looking at signals below the broadband noise.

Crest Factor is the ratio of the peak value of the signal to the RMS value. If this ratio is higher than 25, then the "CREST FACTOR TOO HIGH" legend may be flashed on the screen.

2-12 FREQUENCY- 75μSECOND CHECK:

This test is identical to the frequency response test with the exception that the high end response has been modified with a 75μsecond boost. The use of this test with a test record is covered in Paragraph 3-14. To implement this test, push the FREQ RESP and SPOT FREQ buttons at the same time. The letters FS will appear at the top left of the display. Also on the top, will be the offset level and the L.S.L. setting. Press L&R, SINGLE and BOTH. A curve starting at 40 kHz to the L.S.L. frequency will be plotted. A 6 dB/octave slope will start at 40 kHz. At 2.20 kHz the +3 dB point on the curve can be measured if the cursor is moved to this frequency. The curve will become exponentially flat and will remain flat to 20 Hz.

2-13 NOISE CHECK

Press: L&R, NOISE, REPEAT, NAB, FLAT, BOTH. The screen will show a bar graph with both the left and right channel bars displaying the noise levels relative to the input reference level. The legend at the top of the display shows "FLAT" (no frequency weighting), "L-XX dB R-XX dB" (levels relative to the input reference level), "10 dB/D" (scale factor). The top of the scale is 0 dB, the bottom is -100 dB.

When the one-third Octave Spectrum Analyzer board is added to the 1510A, a frequency response graph will be present on the display. The plot of the noise will be the shape of NAB weighted curve if the WEIGHTED button is depressed.

If the 1510A is in the MANUAL mode, the unit can be used as a tuned voltmeter. Move the cursor to the desired filter frequency. A discrete signal can be measured in the presence of noise. The display will show the input level with the noise reduced by 6 dB at 20 kHz. The noise reduction is more as the filter frequeny is lowered. This is because the signal is going through the 1/3 octave filters before being measured. (See Para. 3-15 on the 1/3 octave option specifications.)

2-14 THEORY OF OPERATION OF REFERENCE LEVELS

Figure 7 is a block diagram of the 1510A output and input circuits connected to a tape recorder. The 1510A front panel is shown above the block diagram.

The figure shows that the 1510A has two output attenuators: one manual, and one automatic. The manual attenuator is operator-controlled, and is used to set the 1510A output level. This level can be called the output reference level and is adjusted with the 1510A in the AC Volts test mode. When in this mode a mid-band test signal of 1 kHz is present at the 1510A output connectors, with the microprocessor setting the automatic attenuator to 0 dB. For other tests, the microprocessor uses the automatic attenuator to adjust the output test signal relative to the output reference level as required. One example of this is in the Azimuth test where the signal is automatically set 20 dB below the reference level.

The output "OFFSET" buttons (under FREQ RESP and CHAN SEP buttons) do not affect the output level of any other test except for frequency response and channel separation. They command the microprocessor to offset the output test signal level with respect to the output reference level when performing these two tests. Once the 1510A Output Reference Level has been adjusted for a specific recorder being tested, the output level should not be readjusted for any normal subsequent testing on that recorder. Neither should the recorder level control be readjusted. Figure 7 shows that the 1510A measures input test signals with autoranging circuits and then displays the results. For several different tests, the results are not displayed in volts, but in "dB" because that is the measure of interest. The dB measurement must have a "reference" or "set" level. This level is the 1510A Input Reference Level, and is normally the level present at the 1510A input for a 0 VU playback level of a tape recorder.

This level is put into the 1510A's digital memory whenever the 1510A is in the AC Volts mode and the INPUT REF SET/RECALL button is pressed.

2-15 REFERENCE-LEVEL TEST TAPES

Some 1510A users will want to verify that the proper recorded flux density (for example, 185 nW/m for ANSI reel-to-reel tape), corresponds to specific metered record and playback levels (0 VU for example). For those users, they are reminded that one must start with a reference-level test tape on the recorder. This tape is played back and used to calibrate the monitor VU meter and to set the recorder output level to the desired 1510A input reference level.

The flux density for the test tape and the tape recorder for a 0 VU reading on the playback meters must be known before any adjustments are made. If the flux density is the same for the tape and the tape recorder, then the first step is completed. However, if the test tape has a different flux density then is required by the recorder, then a correction factor or number must be calculated to determine the correct VU setting. This figure can be found by determining the ratio of the two fluxs in dB. If, for example, the reference tape is 185 nWb/m, and the tape recorder

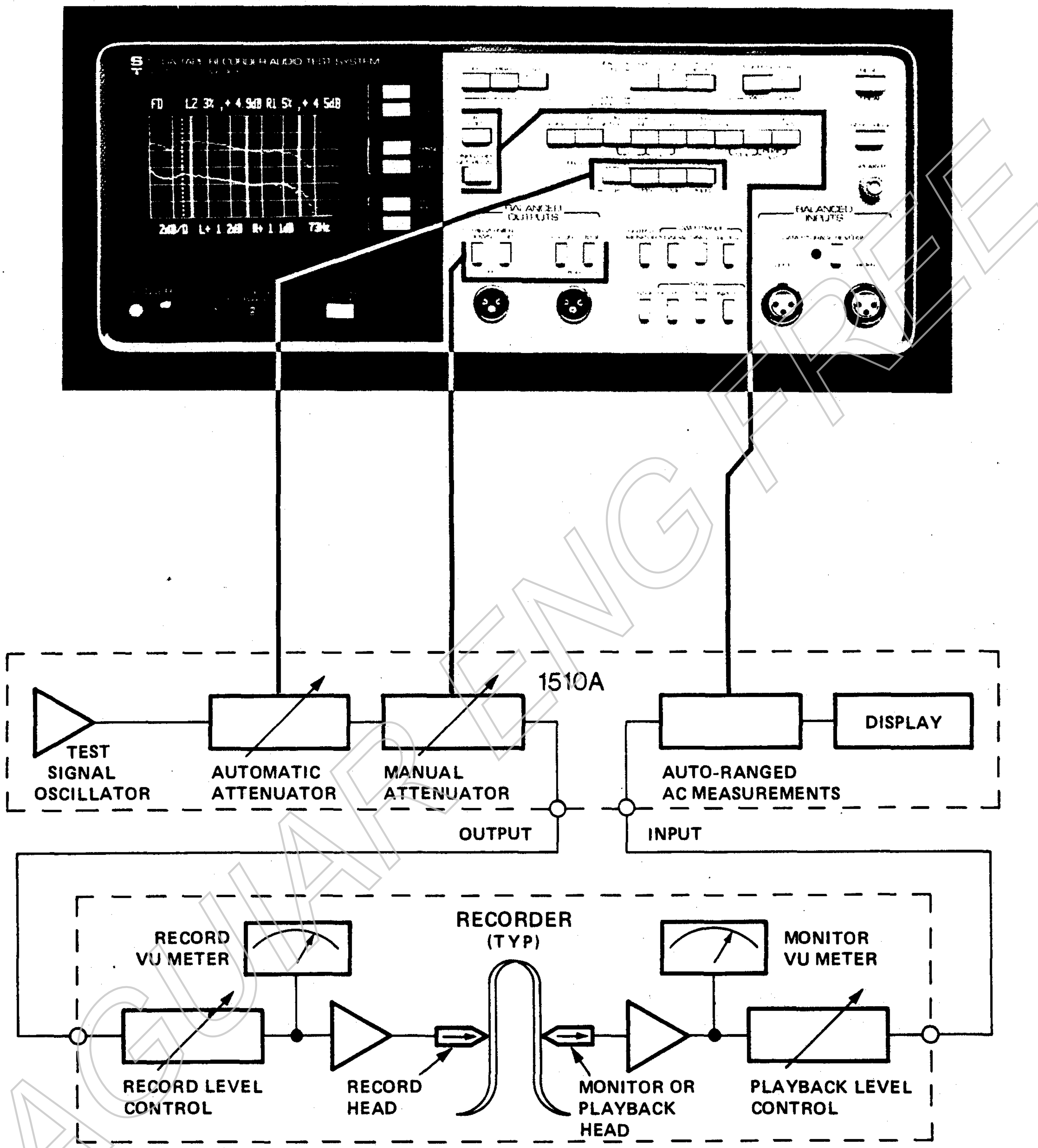


Figure 7. 1510A Reference Levels

needs a flux density of 320 nWb/m for a 0 VU reading, then the ratio is: tape flux/VU meter flux = 185/320 = .578 = -4.8 dB. When the tape is played on the recorder, the meter should be adjusted to read -4.8 dB. Before the 0 VU adjustment and measurements are made, adjust the playback level and balance controls to the mid-position or as required by the tape recorder specifications. The 1510A should be displaying the same playback levels for both channels. The record level can be adjusted and calibrated next by removing the reference-level test tape and replacing with the tape recommended by the recorder specifications.

If the recorder manufacturer requires a specific signal voltage level at the recorder input to produce the 0 VU record level, go to OUTPUT MONITOR mode and adjust the output controls for that level. Return to manual mode. Then adjust the record VU meter calibration if required. Also check and adjust record channel balance as necessary.

It is now possible to verify that a 0 VU record meter reading corresponds to the proper recorded flux density on the tape. Since the monitor VU meter was previously calibrated using the reference-level test tape, by adjusting the record VU meter calibration so it matches the monitor VU meter calibration, the record meter is now calibrated to the proper flux level.

SECTION 3

APPLICATIONS & OPTIONS

3-1 RECORDER TEST PROCEDURES

This section contains detailed test procedures for using each of the 1510A test functions, followed by an abbreviated test procedure that can be used as a guide for testing a typical tape recorder.

In the following procedures, the use of a three-head stereo tape recorder is generally assumed. (A "three-head" recorder is one having separately connected erase, record, and playback heads which allows monitoring of the signal from the tape while simultaneously recording on the tape. The record and playback heads may be in the same or separate housings.) Using a "two-head" recorder (erase head and combination record/playback head) is acceptable, but the tape must be rewound after each recorded test before the 1510A START INPUTS button is pressed. When differing techniques are required due to the type of recorder being evaluated, the correct procedure for making a particular test can be easily inferred from the description given in this and preceding manual sections.

The procedures are given in the following order.

1. Cable Verification
2. Azimuth Alignment
3. Playback, Record, and VU Meter Level Adjustments
4. Distortion
5. Frequency Response Tests
6. Noise
7. Channel Separation
8. Speed
9. Drop-out
10. Flutter
11. MOL

The first five procedures should be performed first and in the order listed. The azimuth alignment has a very strong influence on the high-end frequency response. If the azimuth is far off, it could affect the mid-band level. The mid-band level adjustments (playback, record, and VU meter adjustments) must be correct before one has the proper reference for doing frequency response tests.

In general the remaining listed tests can be made in any sequence since they do not involve any interacting adjustments. Some VU meters are calibrated making 0 VU correspond to a specific distortion level on a specific tape type. This would have to be done using the Distortion-3rd Harmonic test.

The recorder manufacturer's recommendations should always be followed.

CAUTION: Before making any of the following tests, be sure that the recorder heads, tape guides, and other mechanisms are demagnetized and cleaned.

3-2 CONNECTING THE RECORDER TO THE 1510A

Connect one end of a Female XLR cable to the LEFT and RIGHT OUTPUT connectors on the 1510A. Connect the other end of the cable to the appropriate left and right line input connectors on the recorder.

In a similar manner, connect male XLR cables between the LEFT and RIGHT INPUT connectors on the 1510A and the appropriate line output connectors on the recorder.

Connect both the 1510A and the recorder to the proper AC power source, and turn on the power switches to both.

3-3 CABLE VERIFICATION

To insure that the cables are connected properly, press RIGHT, AC VOLTS, SINGLE and BOTH. Put the tape recorder into Source so the input to the recorder can be read by the 1510A. The RIGHT VU meter of the recorder and the RIGHT channel of the 1510A should show a signal present. If the level control on the tape recorder is set for about the center position then adjust the level on the 1510A for reading of 0 VU on the recorder's meter. The 1510A AC Volt meter should indicate a signal of around 0 dBm. Refer to the manufacturer's specifications for the correct input level for 0 VU reading. However, at this time, it is not necessary to have a perfect reading. Now go to the L&R channels and start BOTH. The meters on the tape recorder should be near the same level and the readings between the left and right channels on the 1510A should also be equal.

3-4 AZIMUTH ALIGNMENT

Load the Reproduce Alignment Test Tape (hereafter referred to as "test tape") into the recorder. Make sure the recorder is outputting the tape signal and not the source signal. IMPORTANT: This tape cannot be used with a monaural tape recorder (see the last paragraph in this azimuth alignment procedure). Start tape playback with output level more than 20 mV. Press AZIMUTH, SINGLE, and START INPUTS buttons. Four vertical bars will appear on the center line (the zero degree phase error line). The height of the bars varies continuously, indicating the amount of phase error between the two channels. The bars represent frequencies of 2.8, 5.7, 11.8, and 15.8 kHz.

On recorders having poor response, the 15.8 kHz bar may not appear or may give a false reading. In that case, use the remaining bars.

Adjust the playback head azimuth until the 2.8 kHz (left hand) bar has as small a height (phase error) as possible. Adjust the remaining bars from left to right one by one, until all the bars have as little phase error as possible.

If head azimuth is so far off that a measurement of 2.8 kHz cannot be made, go to AC Volts and adjust head azimuth for maximum output. Then go to Azimuth and adjust for minimum phase error.

To read the amount of phase error at the four azimuth frequencies, press the STOP button on the 1510A. Move the cursor to each bar in turn. Phase error in degrees, and, frequency will be displayed under the graph.

To align the record head azimuth, stop the recorder and remove the "test tape". Insert a good quality blank tape in the recorder. Press AC VOLTS and START OUTPUTS buttons. Use the output control on the 1510A and the record level control on the recorder to set a level of approximately 0 VU.

Press: AZIMUTH, START OUTPUTS. The record level will drop 20 dB. Start recorder in the record mode, with the playback from the tape recorder feeding the 1510A LEFT and RIGHT INPUTS. Press START INPUTS button.

As in playing back the "test tape" four (or three) vertical bars will appear on the display; however, this time the record head azimuth should be adjusted (to match the playback head alignment). Adjust the record head so that all the bars have as small a height from the baseline as possible. It should be noted that the azimuth on a cassette tape recorder can be affected by the record bias level, tape shell mechanics and tape curvature. A good way to determine if there is a problem with the shell or tape is to flip over the tape cassette and recheck the azimuth to see how each side compares.

For the azimuth alignment of a monaural recorder, playback any standard azimuth alignment tape, with the recorder output feeding the 1510A LEFT INPUT. Press: LEFT, AC VOLTS, and START INPUTS. Adjust the playback head for the highest signal reading.

3-5 PLAYBACK, RECORD, AND VU METER ADJUSTMENTS

Operators not familiar with the use of reference-level tapes, the calibration of VU meters, and the concept of dB measurements should read the theory of operation given in Paragraphs 2-14 and 2-15.

A. ADJUSTMENT PROCEDURE (without test tape)

NOTE: This procedure assumes the user does not want to use a reference-level test tape. Even if a reference-level test tape is used, read this section for background details, then refer to Paragraph 3-5B.

1. Setting the Output Reference Level

a. Press L&R, AC VOLTS, and OUTPUT MONITOR buttons. NOTE: Pressing the OUTPUT MONITOR button is equivalent to connecting the 1510A input connectors to the 1510A output connectors and pressing the START OUTPUTS and START INPUTS buttons. The test signal level at the 1510A OUTPUTS is now being measured and displayed. Put the recorder in the record mode.

b. If the recorder manufacturer requires a specific signal voltage level at the recorder input to produce the 0 VU record level, adjust the 1510A output controls for the level in OUTPUT MONITOR MODE. Then adjust the record VU meter calibration, if required. Also check and adjust record channel balance as necessary.

c. If a specific test voltage level at the recorder input is not required, adjust the record level control, if any, to a low sensitivty (this requires a high 1510A output level), since this makes all subsequent testing less sensitive to noise disturbances at the recorder input (1.0 V and 0 dBm are two convenient and sufficiently high levels).

d. If a specific test voltage level at the recorder input is not required, and the recorder does not have a record level control, simply adjust the 1510A output as necessary to produce a 0 VU indication on the record VU meters.

2. Setting Input Reference Level

NOTE: If a reference level test tape is not used, the 1510A output reference level must be adjusted first as described in the above four steps.

a. Press L&R, AC VOLTS, and any SWEEP MODE button. Any SWEEP MODE button stops the OUTPUT MONITOR mode, thereby reconnecting the 1510A measurement circuits to the 1510A INPUTS, and (when in the AC VOLTS mode) prepares the 1510A to operate as a fixed frequency signal source plus a dual channel ac voltmeter.

b. For a three-head recorder, put the recorder in the record and tape monitor mode. (For a two-head recorder, see Step f). Press BOTH on the 1510A. The monitor VU meters, should be indicating 0 VU. Adjust meter calibration, if required. Adjust playback level and balance control to the mid-position. The 1510A should be displaying approximately the same playback level for both channels. Adjust the recorder as required to obtain this condition.

c. Press LEFT (or RIGHT), BOTH buttons. This prepares the 1510A for using the INPUT REF SET/RECALL button. If both Left and Right channels are being measured (L&R button pressed), when the INPUT REF SET/RECALL button is pressed, the 1510A uses the right channel as the reference.

d. Adjust the recorder output level control for the manufacturer's recommended recorder output test level. If none is specified, adjust for a high level which will make the test measurements less sensitive to various noise sources. However, note that the <u>Distortion & MOL tests will produce levels over 20 dB higher than the presently set level.</u>

e. When the recorder output signal is at the desired test level (corresponding to a monitor VU meter indication of 0 VU), press the INPUT REF SET/RECALL button. Note that the 1510A input reference level now appears at the top of the display. This level will be used for subsequent distortion, MOL, frequency response, and noise measurements. When in these test modes, the input reference level can be recalled by pressing the INPUT REF SET/RECALL button. The level will appear momentarily at the lower left of the display.

f. For a two-head recorder, put the recorder in the record mode. Press START OUTPUTS button on the 1510A, and record the test tone for a few minutes. Press the 1510A STOP button. Stop the recorder and rewind the tape. Put the recorder in the playback mode. Press 1510A START INPUTS button. Check and adjust the recorder monitor VU meters and balance control, if any, as described for three-head recorders in Step b. Press LEFT (or RIGHT) and START INPUTS buttons. Adjust recorder output signal to the desired test level as described for three-head recorders. Press the INPUT REF SET/RECALL button.

B. ADJUSTMENT PROCEDURE (with test tape)

The procedure when using a test tape is similar to the procedure when not using one. However, the overall sequence is reversed.

1. First, use the reference level test tape to adjust the monitor VU meter calibration, playback balance, and recorder output level as previously described. Also set the desired input reference level into the 1510A memory by pressing the INPUT REF SET/RECALL button.

2. Next remove the test tape from the recorder, load a blank tape, and make adjustments previously described in Paragraph 3-5A Steps 1a through 1d with one important addition: it is now possible to verify that a 0 VU record meter reading corresponds to the proper recorded flux density on the tape (since the monitor VU meter was previously calibrated using the reference level test tape) by adjusting the record VU meter calibration so it matches the monitor VU meter calibration.

3-6 DISTORTION

A. DISTORTION vs. PLAYBACK LEVEL

For a normally operating audio tape recorder, the third-harmonic distortion (HD3) is entirely due to tape saturation, and at normal operating levels is lower than the total harmonic distortion (THD) value. This is because the THD measurement includes the broad band noise of the tape recorder and tape, whereas the HD3 figure is not significantly effected by noise because of the much narrower bandwidth. The second harmonic distortion (HD2) is normally much lower than HD3. Any significant amount of HD2 probably indicates an electronic fault or a magnetized part along the tape path. Both distortion tests are executed using the procedure given below.

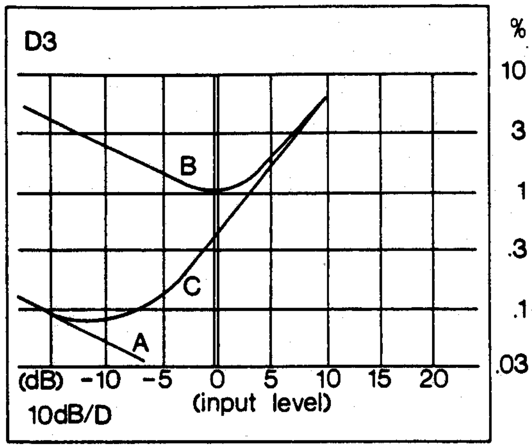
Press: LEFT DISTORTION - 3RD (or 2ND), SINGLE, 315, & BOTH. A series of "steps" will appear on the display. Each step is the result of distortion test made at a different test level. The test can be stopped at any time by pressing the STOP button, or by setting the L.S.L. to some desired level before beginning the test; otherwise, it will automatically stop at -10 dB. In the After-Test mode, legends on the top and bottom of the display show the amount of 3rd harmonic distortion in percent and dB respectively for each channel. The values of distortion are shown for the various input signal levels as indicated by the cursor position. The input test signal level is displayed in the lower right corner. The signal level extends from +20 dB to -10 dB, relative to the input reference level and is shown in Figure 8. The plot may not reach +20 dB because of tape saturation. The double vertical line is the 1510A reference level which normally corresponds to 0 VU on tape recorder. The THD curve was drawn on top of the HD3 curve to show typical values between the two distortion methods.

It is normal for an audio tape recorder to exhibit a positive distortion vs. test level slope in the region around 0 dB test level, as shown in Figure 8, and to exhibit a negative distortion vs. test level slope in the region around the -10 dB test level.

Distortion readings should not be taken from the negative slope or valley regions because these are noise-limited measurements. They are well above the 1510A noise limit, but are limited due to the tape noise from the recorder. Figure 8 shows the noise floor in the measurement due to typical tape noise.

B. DISTORTION vs. VU METER LEVEL

On some recorders, "0 VU" level is adjusted to indicate the record level at



A. Narrow band noise floor of the tape and recorder.
B. Total Harmonic Distortion curve made by a Sound Technology 1701A.
C. 3rd Harmonic Distortion curve.

Figure 8. 3rd Harmonic Distortion

which a specific distortion level is produced, using a specific type of tape. If the preceeding level adjustments and tests were done with the correct type of tape, then proceed as follows after a distortion curve has been acquired. In the After Test state, move the CURSOR to the desired distortion reading. Read the test level at the lower right corner of the display. This is the error in the VU meter adjustment. For example, if the test level indicates +2 dB, the VU meter is indicating 2 dB too high. To correct, press MANUAL and START OUTPUTS. The record level meter (VU meter) will be indicating near +2 dB. Now adjust the VU meter calibration to produce an indication 2 dB lower or 0 VU. This is the correct calibration.

C. DISTORTION LEVEL REFERENCE FOR NOISE MEASUREMENT

Noise level specifications on recorders are sometimes referenced not to 0 VU signal level, but to another signal level; e.g., one that produces 3% distortion. The 1510A Noise test measures noise level relative to the 1510A input reference level which normally is set to correspond to 0 VU. To obtain a correction factor to the 3% distortion signal level, execute a Distortion-3rd test in the MANUAL mode with the desired tape in the recorder. Then move the CURSOR to indicate the 3% distortion point. The UP & DOWN buttons may be useful to get closer to the 3% point. When the +V--> indication is on the top right of the screen, the output level of the recorder is 1/2 dB lower than indicated at the lower right of the display. The -V--> is 1/2 dB higher. The 0.1 dB vernier may also be used to find the 3% distortion, but be sure to return the output signal back to the reference level. Suppose the test level (in the lower right corner of the display) now indicates +5 dB. This is the correction factor that should be subtracted from the Noise test indication. Suppose the Noise test indicates -48.2 dB. This is relative to the 1510A input reference level, normally 0 VU. The noise level relative to the 3% distortion level is -53.2 dB.

3-7 FREQUENCY RESPONSE TESTS

The general procedure for making a frequency response test is described, followed by more specific procedures for high speed tests and combination frequency response/distortion tests.

A. FREQUENCY RESPONSE

Press: L&R, FREQ RESP, -20 dB Offset, and SINGLE. Load a tape into the recorder. Start recorder in the record/playback mode. Press BOTH buttons.

Upon playback of the tape, a trace of the frequency response begins appearing on the 1510A display. In the L&R mode, first the response of the right channel is plotted, then the response of the left channel is plotted. When the sweeps have been completed, the CURSOR can be moved to any point on the display for signal level vs. frequency measurement. Use of the EXPAND, SPLIT, and LOW SWEEP LIMIT buttons may be helpful. For the Frequency Response test, the EXPAND and SPLIT buttons are active during the Active-Test state as well as during the After-Test state.

Before pressing the UP, DOWN, or SPLIT button, note that the center horizontal line on the display graticule represents the test offset level. For example, if the test were made at -20 dB Offset, the center line is -20 dB. Set the L.S.L. at 1.00 kHz and then press SPOT FREQ. Repeat the above procedure.

When in MANUAL sweep mode, the UP and DOWN buttons act as frequency vernier controls. The output frequencies will change about 3% when these buttons are used.

B. SPECIAL TEST LEVELS

The offset buttons make it very convenient to do frequency response tests at levels from -20 dB to +10 dB, relative to the preset 1510A output reference level. Tests can be made at most any other arbitary level by using the output controls. However, if this is done, reset these controls to their output reference level position before proceeding to other tests. A suggested procedure for using these controls follows.

Assume a frequency response test at -26 dB, relative to 0 VU, is required. Press FREQ RESP, 0 dB Offset, and OUTPUT MONITOR. The recorder meter should be indicating 0 VU because the recorder record level control and the 1510A output control were previously adjusted to this condition. If required, trim-adjust either control to obtain 0 VU. Now observe and record the 1510A reading (in dBm). This is the 1510A output reference level. Now press OUTPUTS, 20 dB ATTEN, and adjust the output level to obtain a reading 26 dB below the 1510A output reference level reading. Now press SINGLE, for example, and execute the frequency response test. Use the UP control to center the graph. After completing the test, return to OUTPUT MONITOR and re-adjust the output controls to produce the 1510A output reference level.

The offset buttons can be used at positions other than 0 dB, in conjunction with the output controls. For example, the test at -26 dB could have been done by pressing the -20 dB offset button instead of the -20 dB attenuator button. Notice that the displayed graph now appears about 6 dB below the horizontal center line instead of 26 dB below.

To obtain maximum 1510A output level, set the output to maximum and press the +10 dB offset button. When in Frequency Response or Channel Separation test modes always remember to press 0 dB offset before re-adjusting the 1510A output to the output reference level in output monitor.

C. HIGH-SPEED FREQUENCY RESPONSE

For normal frequency response testing, the 1510A will track, measure, and display response slopes up to 60 dB per octave with full accuracy. For some high-frequency adjustments, it is more useful to provide a faster sweep speed at lower frequency measurement accuracy. This mode is available by pressing the FAST button. The slope accuracy is only 30 dB per octave.

D. FREQUENCY RESPONSE/DISTORTION

Recorder bias adjustments affect both the high-end frequency response and the mid-band distortion. Therefore, the 1510A offers a combination frequency response/distortion test mode. To use, press the FREQ RESP and 3RD DISTORTION buttons at the same time. Now set the L.S.L. to the lowest frequency to be swept. Press REPEAT. After pressing BOTH, a frequency response test will be made from 40 kHz down to the L.S.L. frequency at the offset level selected. Then a third-harmonic distortion test is made at approximately 0 VU at the same frequency that the Harmonic Distortion tests used. The frequency response is displayed graphically and the distortion level (in %) and distortion test level (in dB) are displayed above the graticule area. The complete test sequence is repeated at a rate fast enough to observe the bias adjustment trade off between distortion and high-end frequency response.

Another method is to make sure that the 3rd harmonic distortion at 0 VU is at specification or lower. Go to the MANUAL mode in frequency response and after pressing BOTH, move the cursor to the highest frequency of interest. At this frequency adjust the bias for the desired response. Go to SINGLE sweep mode in FREQ RESP/3RD DISTORTION and press BOTH.

Now verify that the response curve and the distortion measurement are per the desired specifications. You may want to repeat this several times to get the best trade off possible.

In some cases the noise of the recorder may be significant and will cause the frequency response test to not work correctly. The specification requires that the signal to noise ratio is at least 20 dB. Thus, if the response curve is made at -20 dB, the flat noise reading must be lower than -43 dB. This allows the signal to roll off 3 dB before the test will stop plotting the correct frequencies and level. The symptom is that while the frequency response curve is being developed, the correct data will be replaced by random frequencies at random levels. This will normally happen at low frequencies.

3-8 NOISE

To measure tape noise, press the L&R and NOISE buttons on the 1510A. Press either the NAB, JIS, or CCIR/ARM, and WEIGHTED or FLAT buttons. (Details on the measurement standards are given in Section 1, page 18.) Put recorder in the record/playback mode. Press BOTH. The 1510A display will show the noise level (20 Hz to 20 kHz) in dB below the input reference level, with the noise value displayed on a bar graph. The meter scale is in dB, with 0 dB at the top and -100 dB at the bottom.

In this test the recorder inputs are terminated in the output impedance of the 1510A.

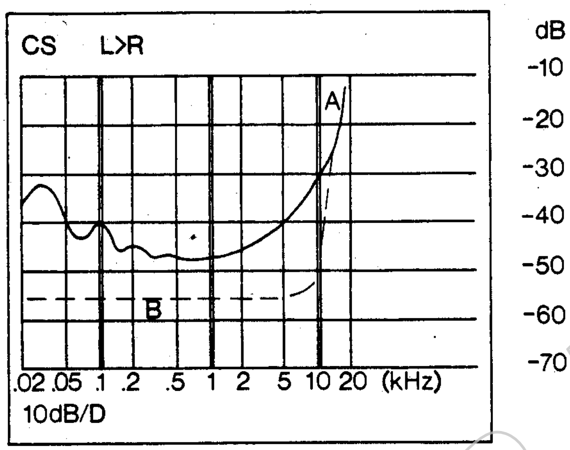
3-9 CHANNEL SEPARATION

To measure the left channel separation, press: LEFT, CHAN SEP, 0 dB offset, and SINGLE. The signal will be applied to the right channel and measured for the reference level. The display will indicate this by the notation "R>L". The level of the signal then appearing in the left channel will be measured, divided by the test level in the right channel, and then displayed in dB versus frequency.

Start the recorder in the record/playback mode. Press BOTH. Channel separation is displayed as a graph, starting at 20 kHz and ending at 20 Hz (unless the LOW SWEEP LIMIT SET button was used to select a different low frequency limit). The display resolution is 1/3 octave. After the test has stopped, the channel separation can be read using the cursor. Figure 9 shows a typical recorder channel separation test display.

Channel separation test results require careful interpretation. They can be invalidated over certain frequency ranges because of the test level used, the noise level from the recorder, or by recorder frequency response limitations at the high or low ends of the test band. These conditions are described as follows:

A. Over the entire frequency range, a valid channel separation measurement cannot be made that exceeds the difference, in dB, between the test level measured in the reference channel and the audio-band noise level in the disturbed channel. The test level vs. frequency can be observed by executing a frequency response test on the reference channel at the same level as is used for the channel separation test. The audio-band noise level can be observed by executing a NOISE, ANSI, FLAT test on the disturbed channel. If the 1/3 octave filter option is used, the noise problem can be reduced considerably. Because this filter is constant Q type, the noise reduction improves as the frequency is reduced. At 20 kHz there is more than 6 dB noise reduction and at 1 kHz there is more than 20 dB reduction of noise.



A. Hi-end noise limits due to limited frequency response
B. Mid-band noise limit for -55 dB noise level

Figure 9. Channel Separation

B. To gain a wide dynamic test range, one cannot necessarily test at +10 dB offset. Such a level may result in hard saturation at some point in the recorder which could in turn produce erroneous channel separation test results. Consult the recorder manufacturer's information for guidance on the proper test level. Otherwise, 0 dB offset is a reasonable level at which to start. Test results that are essentially the same for two different test levels are generally valid.

C. Recorders often exhibit very deep and very sharp (high Q) channel separation notches over the low end of the frequency range (head bumps may be one cause of this problem). On a 1/3 octave display the results sometimes appear to be noisy or not a smooth curve, even though they are accurate. To determine if this situation exists, observe the locations of some of these low-frequency channel separation results. Then repeat the test on the same channel. If the test results repeat, then the test is valid and not due to noise. Also do a frequency response curve to observe the low frequency response and head bumps.

3-10 SPEED

To check absolute speed error using a standard speed reference tape, do the following: Press: LEFT (or RIGHT), SPEED, and 3.0 or 3.15 kHz (depending upon tape reference frequency). Load the speed reference tape into the recorder, and start the recorder in the playback mode. Press START INPUTS button. The letter "I" indicating that the 1510A is reading the input signal will appear in the upper left corner of the display.

After about 13 seconds, a trace will start to appear at the left side of the display, representing the speed error for the first 10 second measurement period. The trace will grow in 10 second steps as long as the speed reference tape has a signal. The Instantaneous Speed Error (ISE), in percent, is shown above the graticule. To stop the test, press the STOP button. The cursor can be used to show the speed error relative to the reference tape at any 10 second step of the test. Drift from any cursor reference point can be obtained by pressing the VERT REF-DISPLAY button. Drift between that point and any other point selected by the CURSOR is shown, in percent, below the graticule. By using the EXPAND button, the vertical scale factor can be changed from 0.2% per division to .02%.

To check speed error (or drift) for two different operational conditions (such as an empty and full reel): execute a speed error test as described above for a minute or two at the empty reel condition. Then, without stopping the test, fast forward or reverse the reels to the full reel condition. Continue the speed error test at this condition for a minute or two, after noting the test time on the 1510A display. Now press STOP and analyze the test data using the CURSOR.

To make a speed test tape on a high quality recorder for testing recorders of lesser quality, load a blank tape into the recorder. Press LEFT (or RIGHT), SPEED, 3.0 or 3.15 kHz, START OUTPUTS. Begin recording on the tape. The display will show the legend "0" and "REMAINING TIME: 630 SECONDS." As the test progresses, the remaining recording time shown above the graticule will drop at 10 second intervals. If the test is to be stopped before 630 seconds (10 1/2 minutes) have elapsed, press the STOP button on the 1510A at the desired time.

3-11 DROP-OUT TEST

Drop-outs can be measured on a pre-recorded tape or you can measure drop-outs as they are recorded using a three-head recorder. The drop-out frequency buttons on the 1510A only affect the output signal's frequency. They need not be set when using a prerecorded tape. High quality tapes may show few or no drop-outs, especially if they're in near-new condition. When the test stops after 1,000 seconds or if you push STOP, the number of drop-outs per 20 seconds will be displayed on the bottom line of the CRT. On the top line of the CRT will be the I..E.C. drop-out categories. These are defined in I.E.C. #94, September 1981. A drop-out is defined in Paragraph 3-17, Page 70.

To measure record/playback drop-outs, select a channel and a frequency, then press DROPOUT, SINGLE & START BOTH. The output signal is 20 dB below the reference level, as defined in the I.E.C. standard. After about 20 seconds, the first data point will appear. It will be on the bottom line of the graticule if there are no drop-outs. Let several more 20 second intervals be plotted, then press STOP. The top line of the CRT will show the categories. They may also be all zero if all the drop-outs do not fall into any of the four categories. (See page 70.)

3-12 FLUTTER

To measure record/playback flutter, press LEFT (or RIGHT), FLUTTER, either NAB, JIS, or DIN/ANSI, and FLAT or WEIGHTED. (Details on the measurement standards are given in Section 1, page 18.) Start recorder in the record mode, with recorder playback feeding the LEFT INPUT (or RIGHT INPUT) of the 1510A. Press START OUTPUTS and START INPUTS buttons, or START BOTH.

To measure playback flutter, use a standard flutter test tape, and press NAB (3.0 kHz), JIS (3.0 kHz) or DIN/ANSI (3.15 kHz), and FLAT or WEIGHTED buttons as required to match tape frequency and measurement standards. Start recorder playback. Press START INPUTS button.

The 1510A display will show the flutter (0.2 to 200 Hz bandwidth) as a bar on a graph, with the scale factor above the graph. A 2 Sigma, statistically averaged reading (95% of peak), in percent, is shown at the top of the display.

3-13 MOL

The following is an example of how to do a 315 Hz MOL test on the left channel, and then a 10 kHz test on the left channel, using the DATA STORAGE REVERSE button.

A. Start tape machine in Record, with monitor on the recorder on tape rather than source.

B. On the 1510A, select AC VOLTS, LEFT, SINGLE, START BOTH.

C. Set the Reference and select the MOL test by pushing SPEED & FLUTTER at the same time.

D. Set the desired LOW SWEEP LIMIT by moving the cursor to the desired level and then pressing the LOW SWEEP LIMIT button.

E. Now move the CURSOR to -2 dB and note that "C315Hz" is in the upper right corner of the CRT. Start the test by pushing the START BOTH button, and it will sweep to the L.S.L. (An error message will be generated if only START OUTPUTS or START INPUTS are pressed. If this occurs, wait for the message to clear and then move the cursor back to -2 dB and restart the test using START BOTH.)

F. When the sweep is done, press the DATA STORAGE REVERSE button, then move the CURSOR up until the test frequency reads "C10.0kHz". Start the test.

G. When the sweep is done, press the DATA STORAGE REVERSE button and press L & R. Both curves will be displayed. The test frequency of each curve will be shown on the top line of the CRT and the data on the botton line.

The cursor acts as it does in all other tests, except that just before starting the test, it should be moved to the position that selects the desired test frequency.

In the MANUAL mode, the setting of the cursor just prior to starting the test determines the test frequency. After starting the test, the cursor controls the attenuators only.

3-14 ABBREVIATED TEST PROCEDURE

This procedure is to be used only as a guide for adjustment and performance testing of typical three-head recorders. Refer to previous sections of this manual for more detailed information.

The recorder manufacturer's recommendations always should be followed. Before making any adjustments or tests, be sure that the recorder heads, tape guides and other mechanisms are demagnetized and clean.

A. CABLE VERIFICATION AND INITIAL LEVEL SETUP: (Do the funtions under PRESS before going to the COMMENTS for each step of the test.)

	PRESS:	COMMENTS:
1.		After connecting the input and output cables between the 1510A and the tape recorder, put the tape recorder into the source monitor mode.
2.	RIGHT AC VOLTS SINGLE BOTH	The right meter should be adjusted to read 0 VU. There should be a reading on the 1510A RIGHT channel of several hundred millivolts.
3.	L&R BOTH	Both VU meters will be at or near 0 VU and both channels should read approximately the same on the 1510A display.

B. AZIMUTH:

1.		Load the "test tape" into the recorder and set to play.
2.	AC VOLTS L&R START INPUTS	Left and right readings approximately the same on the 1510A display. When the Azimuth test signal starts then go to Step 3.
3.	AZIMUTH START INPUTS	Observe 4 vertical bars with varying height. Adjust playback head azimuth to obtain smallest bar height on the left bar and then continue adjusting for minimum height of each of the next three bars. NOTE: It may not be possible to achieve a minimum reading on 4th (right hand) bar. In this case, adjust 3 bars for minimum height. Load blank tape (as recommended by manufacturer) and set recorder to "Record" with Playback feeding into the 1510A.
4.	AC VOLTS L&R OUTPUT MONITOR	Adjust 1510A OUTPUTS and/or recorder inputs controls for 0 VU on recorder meters
5.	AZIMUTH BOTH	Observe 4 vertical bars. Adjust record head for smallest vertical height of bars.

C. SET LEVELS:

1.		Load "test tape" into the recorder and rewind to the beginning of the tape. Set the recorder to play.

PRESS:	COMMENTS:
2. AC VOLTS L&R SINGLE START INPUTS	Adjust recorder playback circuits for proper levels (read from 1510A) and adjust playback meters to manufacturer's specificiations. Load blank tape of recommended type onto recorder. Set to "Record" with Playback feeding into 1510A.
3. OUTPUT MONITOR	Adjust 1510A outputs to recorder manufacturer's recommended line input test level, which is usually the same level as Step 2. From this step on, do not change the output settings on the 1510A. Set recorder input level controls to manufacturer's recommended test position.
4. AC VOLTS L&R BOTH	Observe the voltage reading from recorder. It should be the same or similar to that obtained in Step 2. If levels are substantially different from Step 2, check tape bias and EQ settings on recorder, and refer to manufacturer's instructions before continuing.
5. LEFT BOTH	Verify that voltage reading is the same as above.
6. INPUT REF SET/RECALL	This sets the "0 dB" reference in the 1510A memory for use in subsequent measurements. You have now set output and input calibration on the recorder.

D. DISTORTION:

PRESS:	COMMENTS:
1. 3RD DISTORTION	Move CURSOR to -5 dB.
2. LSL 315 SINGLE BOTH	After completion of the automatic sweep, the 1510A display controls may be used to aid analysis of the data. Verify that the distortion at 0 dB is at, or lower than, the specification of the manufacturer. Adjusting the bias level will change the distortion. The bias will also effect the high frequency response so some caution must be used with this adjustment. NOTE: If the 1510A is put into the MANUAL mode and the CURSOR adjusted such that output level is at or near 0 VU, then adjust the bias level for maximum amount. As this is done, the distortion and level will go down.

PRESS:	COMMENTS:
	Then decrease the bias until the desired value is reached at 0 VU. The bias may need to be readjusted when the frequency response test is made to acheive the desired response at high frequency.

E. FREQUENCY RESPONSE:

1.	Steps 4 through 6 can be done directly, however, a very useful test using the manual mode can be done as follows before going to step 4.
2. MANUAL RIGHT FREQ RESP BOTH	Move the cursor to the highest frequency that needs to be more than -3 dB. Adjust either the bias or record equalization according to the manufacturer's specs.
3. LEFT BOTH	Move the cursor to the highest frequency that needs to be more than -3 dB. Adjust either the bias or record equalization according to the manufacturer's specs.
4. FREQ RESP/ 3RD DISTORITON -20 dB REPEAT LSL BOTH	The Low Frequency Limit is at 1 kHz. The frequency response down to 1 kHz and the 3rd harmonic distortion will be repeatedly measured and displayed. Adjust bias and/or record EQ to obtain optimum response. Use EXPAND, if desired.
5. L&R SINGLE	Set LSL to 20 Hz.
6. BOTH	The complete frequency response of both channels will be measured and displayed. Use EXPAND, SPLIT, and CURSOR POSITION to analyze the results.

F. CHANNEL SEPARATION:

1. CHAN SEP 0 dB LEFT SINGLE BOTH	After the test automatically stops, use the 1510A display controls to analyze the data.

G. FLUTTER:

1.	Load standard prerecorded flutter tape (NAB 3.0 kHz to JIS 3.0 kHz or DIN 3.15 kHz) on recorder and set to play.
2. FLUTTER NAB, JIS or DIN (according to desired test) WEIGHTED START INPUTS	Observe vertical bar graph of instantaneous flutter with statistical average at top of display

PRESS:	COMMENTS:
H. NOISE:	
1.	Load recommended tape type onto recorder. Verify that record, playback and 1510A input reference levels are correct. (See Set Levels Paragraph 3-5) Set recorder to record/playback.
2. NOISE NAB FLAT BOTH	Observe bar graph of noise level referenced to 0 VU with a 20 kHz to 20 Hz bandwith.
I. NOISE LEVEL, REFERENCE TO 3% THIRD HARMONIC DISTORTION:	
1.	If a noise level reference of "3% Third harmonic distortion" is required, follow this procedure.
2. 3RD DISTORTION MANUAL BOTH	Put the tape recorder into record. Move the cursor until the distortion reads as close to 3% as possible. The UP and/or Down buttons may help to get closer to 3%. The vernier may also be used, if returned to correct reference level. Read test level to produce 3% distortion. Add test level to noise level obtained above.
J. SPOT FREQUENCY:	
1. SPOT FREQ 0 DB SINGLE LEFT FAST START BOTH	Observe a segmented frequency response graph for overall performance checking.
K. DROP-OUT:	
1. DROPOUT 3.15 SINGLE LEFT START BOTH	Observe drop-outs per 20 second intervals. If necessary, create drop-outs by quickly pressing and releasing the -20 dB button. Then press STOP and observe IEC categories.
L. SPEED:	
1. SPEED SINGLE LEFT	Select the test frequency to match your speed tape/flutter tape.
2. START INPUTS	Observe speed error in 10 second intervals.

3-15 TURNTABLE and CARTRIDGE TESTING

A. TEST SET UP

The following equipment is necessary to test a turntable and/or a phono cartridge - 1510A Sound Technology Test record (TR150); preamplifier with a RIAA response, and cables.

1. Connect a set of leads from the preamplifier inputs to the 1510A outputs (make sure the 1510A is in the stop mode).

2. Connect a different set of leads from the preamplifier outputs to the 1510A INPUTS.

3. Connect a ground wire from a 1510A front panel ground lug to the preamp ground lug and connect the turntable ground wire to the preamp ground.

4. Set the 1510A to the following: AC VOLTS, RIGHT, -20 dB, -40 dB, OUTPUT MONITOR.

5. Adjust the output level vernier to 2 mV. Set the 1510A to REPEAT and press BOTH.

6. Adjust the preamp level control for a reading of 200 mV on the right channel of the 1510A. Then check that the left channel is also 200 mV. This will calibrate the preamp to a 40 dB gain. The preamp level should not be changed hereafter.

7. Remove the 1510A cables from the preamp inputs and connect the turntable to the preamp inputs. Keep the left and right convention when doing so in order to do channel separation tests.

8. The cartridge and the turntable are now ready to be tested. Follow the instructions on the Test Record Cover and Paragraph 3-15B to know what the 1510A settings should be for the different tests. When the cartridge voltage level is needed, use the first band on the record and divide the value displayed on the 1510A by 100. Note that when frequency response is measured, FREQ RESP & SPOT FREQ buttons must be pushed simultaneously.

B. TR150 TEST RECORD DESCRIPTION OF TESTS

The descriptions below apply to both the quick test and detailed test sections. The quick test section has shorter sweeps than the detailed section, and therefore, less data points will be plotted. The quick section is used generally for verification and the detailed section for calibration.

1. REF LEVEL, BALANCE

This test is used to set the Reference on the 1510A, as with a tape recorder. It is also used to check and/or adjust the balance of the cartridge preamp system.

2. Vertical Tracking Adjust

This test is used to adjust the tracking force of the cartridge. Too little force makes the cartridge jump out of the groove, causing high distortion. Force should be increased until the distortion is minimal, but not increased much beyond this point and never beyond the maximum tracking force recommended by the manufacturer.

3. Relative Phase vs. Frequency

This test is used for checking the phase of the connections to the cartridge, and to a lesser extent, the actual signal phase from the cartridge itself. However, twisting the cartridge in its shell seems to affect azimuth very little, so this test should not be used for alignment.

. Frequency Response & Distortion erses Level (lateral & vertical) Test

The higher quality cartridges may show very little change in reading as the anti-skate tracking force or V.T.A. is varied. These tests can also be used to show the differences between one cartridge and another. The FREQUENCY RESPONSE test can also be used to adjust the cartridge load on the preamp for the best high frequency response.

5. Frequency Response

This test is used for checking the response of the cartridge, and to a lesser extent is used to adjust the V.T.A., vertical tracking angle. The V.T.A. affects the high frequency response. The SPOT FREQ and FREQ RESP buttons must be pressed simultaneously for this test. See 75 μsecond switch in Paragraph 1-4 & 2-11.

6. Distortion verses Level - Lateral

This test is used to adjust the anti-skate control, if available. The anti-skate should be adjusted until the distortion is minimal. Anti-skate can generally be adjusted with any type of signal.

7. Distortion vs. Level - Vertical

This test, like the vertical tracking adjust test, is used to set the tracking force on the cartridge. Unlike the other test, this test sweeps the level. The tracking force should be adjusted to give minimal distortion at the highest level that the cartridge can track. The poorer the cartridge, the lower the levels it can track before jumping from the groove.

8. Channel Separation

This test is used to check the separation between channels on the cartridge. The right channel is driven so the 1510A should be in LEFT.

9. Speed Error

This test is used to check the speed of the turntable and adjust the pitch control if available. This test should not be used for flutter because hole-eccentricity greatly affects the true flutter.

10. Noise

This test is used to measure the cartridge and turntable noise. Note that there is no R1AA compensation on this groove, so the noise is weighted by the RIAA compensation in the preamp. This is the most natural way to measure record noise.

C. TR150 TEST RECORDS SPECIFICATIONS

1. Frequency Response Flattness: ± 1.0 dB

2. Cutting Head Angle: 20 degrees

3. Channel Separation (40-16 kHz): greater than 35 dB

4. 0 dB Reference: 5 cm/sec, rms, lateral, 1 kHz

5. RIAA Recording Compensation is used except above 2.12 kHz where the velocity is contant, therefore, playback treble pre-emphasis is required. The required pre-emphasis is available in the 1510A.

6. Recording Equipment:

Program Console	JVC PC-77
Recording Amplifier	Ortofon GO-741
Cutter Head	JVC CH-90
Cutter Stylus	NDH-2 (diamond)
Record Cutting	1/2 Speed
Lathe	Neumann VMS-70 (Quartz Lock)

7. Residual noise in the quiet groove is not specified due to the fact that this parameter is highly dependent on the condition of the record and the stamping processes.

8. Absolute speed error is not known, but setting the pitch control to get a reading of 0% error will match the speed of the turntable to the speed of the lathe, which is assumed to be very accurate.

9. Typical Residual Distortion - Unknown

3-16 ONE-THIRD OCTAVE SPECTRUM ANALYZER OPTION 007

This option provides the 1510A user with the capability of spectral analysis with one-third octave resolution of the noise, flutter and channel separation tests. Both noise and channel separation are measured from 20 kHz to 20 Hz. Wow and flutter are measured from 200 Hz to 0.5 Hz. The weighted, flat and standard buttons apply to these tests. When the FLAT button is active, the response of the spectral noise and flutter are flat also. The response across the band is within one half dB. When the weighted button is depressed, the response is according to the standard button that is chosen.

A. SPECIFICATIONS

1. Filters satisfy ANSI S1.11-1966 (R1975) Third Octave, Class II, Type 0 requirement:

a. Accuracy: 1.0 dB (Variation of minimum Transmission Loss)

b. Rejection ratio: greater than 60 dB

c. Maximum pass-band ripple: 1.0 dB P-P

d. Center frequency accuracy: better than ±3%

e. Minimum filter slope: 31 dB/octave, typically 50 dB/octave

2. System Dynamic Range: greater than 90 dB.

3. Filter's frequency range: ANSI Type 0, optional range. Includes all Type E and extends down to ANSI band-number -3, 0.5 Hz

4. Noise frequency range: 20 Hz to 20 kHz

5. Flutter frequency range: 0.5 Hz to 200 Hz

B. INTRODUCTION

Upon installation of the spectrum analyzer option, four tests are affected- SELF CHECK, CHANNEL SEPARATION, NOISE AND FLUTTER. Since NOISE and FLUTTER are unique tests, in that they have both vertical bar graphs and graphical information, they behave slightly different than other tests. The following summary describes these differences:

The Sweep Modes only affect the graphical information and do not influence the vertical bar graphs. The bar graphs will always be updated during the test unless STOP is pressed. If REPEAT is pressed, the graphical data will be updated again and again as in other tests. If SINGLE is pressed, the graphical data will stop being updated when it reaches the LOW SWEEP LIMIT, which is set as in other tests.

Because the test does not stop in SINGLE automatically, a potential problem exists of not knowing when the graphical data is finished. To avoid this problem, the graphical data will stop blinking when the sweep is finished. This is useful in FLUTTER because the lower frequency measurements take about 30 seconds each. Since the LOW SWEEP LIMIT is not shown during the test, some indication is needed to show whether the sweep is finished or waiting for the next frequency window.

If SINGLE has been pushed and the sweep is finished, it may be restarted simply by pushing REPEAT. There is no need to push START INPUTS again.

In MANUAL, the cursor position selects a specific third octave measurement band, which is indicated in the lower-right-hand corner of the display. Since the outputs are not variable the cursor will stay on the display and has no effect on the outputs.

If SINGLE, START OUTPUTS are selected for recording a test tape, the outputs will remain on until enough time has elapsed to complete one sweep, or two sweeps if L&R is pushed. After that time, the legend "RECORD COMPLETED" will appear.

Under certain conditions, the graphical data may have points on the graph that are missing. When read by the cursor in the After-Test state, the display may show "LOW" instead of numerical value. This indicates that the level is too low to obtain an accurate reading.

Because of the very nature of noise and flutter, the spectral data may not be entirely repeatable from one sweep to the next or may appear unstable when taking readings in manual. This is normal.

C. USES

1. Noise - 1/3 octave spectral analysis of noise from 20 kHz to 20 Hz with either a flat response or a chosen weighted response. Two noise sources can be compared by using the two channel input to the 1510A.

2. Tuned-dB-Voltmeter - In the noise mode, FLAT response and the reference level set to 1 volt, the option allows the operator to have a constant Q tuned voltmeter reading in dB-Volt values.

3. Channel Separation

The option allows the display of Channel Separation below the recorder's audio-band noise. This plot can be used to display coherent signals that are down in the noise area but may be of great concern. Figure 10 shows the noise limit improvement that the option will provide assuming the audio-band noise is white and where the limiting channel separation measurements are -50 dB with no 1/3 octave board.

4. Depth of erasure

Depth of erasure can be measured at any one third octave frequency, down to the limits established by the one third octave noise floor from the recorder. To measure depth of erasure at 100 Hz, for example, a +10 dB signal at 100 Hz is recorded on the tape with the 1510A in FREQ RESP, MANUAL. The tape is rewound, then (for a three head recorder) erased and monitored with the recorder in Record and Tape Monitor mode. The 1510A is in FLAT, NOISE, START INPUTS. The audio spectrum can be measured and displayed with the 1510A in SINGLE, or only the 100 Hz erasure can be measured with the 1510A in MANUAL SWEEP, CURSOR set at 100 Hz.

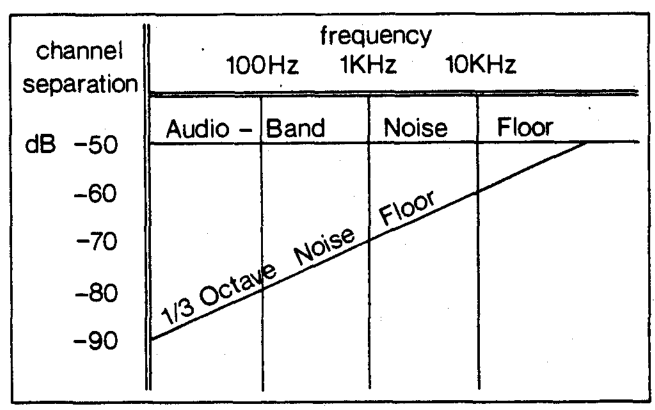


Figure 10. Channel Separation Noise Floor Improvement

3-17 GPIB (GENERAL PURPOSE INTERFACE BUS), OPTION 009

A. GENERAL INFORMATION

The 1510A may be operated under remote control by a suitable GPIB Controller. All the examples and programs contained within are done on an HP85A computer. Complete GPIB capability as defined in the IEEE Std. 488 is shown in Table 6.

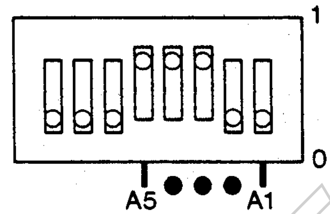
Except for Power, and Speaker, all front panel controls are fully programmable via GPIB. Typical data rate when talking is 550 Bytes/s and when listening is 1 kB/s.

B. ADDRESSING

The GPIB address switch is located on the rear panel. If the address is to be changed, it should be done so with the Power Switch off, otherwise the microprocessor will not read the new address. The address is set with the first five switches, A1 - A5. The last three switches have no function. The address is selectable from 0 to 30 and is factory set at 28. The switch is coded in binary, (base two). Therefore, the factory setting of 28 appears as follows:

The address is:

A1 $0 \times 2^0 = 0$
A2 $0 \times 2^1 = 0$
A3 $1 \times 2^2 = 4$
A4 $1 \times 2^3 = 8$
A5 $1 \times 2^4 = \underline{16}$
TOTAL: $\underline{28}$



GPIB ADDRESS SWITCH

C. REMOTE MODE

In remote, all of the 1510A front panel controls are disabled except those which are not controllable remotely and the Reset button. However, all CRT displays and output levels are valid. In remote, the 1510A may be addressed to talk or listen. When addressed to listen, the 1510A will respond to the Data, Trigger, Clear (SDC) and Local messages. When addressed to talk, the 1510A can issue the Data and Status Byte messages.

Whether addressed or not, the 1510A will respond to Clear (DCL), Local Lockout, Clear Lockout/Set Local and Interface Clear (IFC) messages, and in addition, the 1510A may issue the Service Request message.

Table 6. GPIB Capability

Source Handshake	SH1	(full, $T_1 \approx 2.87 \mu s$)
Acceptor Handshake	AH1	(full)
Talker	T6	(No Talk Only)
Extended Talker	TE0	(None)
Listener	L4	(No Listen Only)
Extended Listener	LE0	(None)
Service Request	SR1	(Full)
Remote/Local	RL1	(Full)
Parallel Poll	PP0	(None)
Device Clear	DC1	(Full)
Device Trigger	DT1	(Full)
Controller	C0	(None)
Bus Drivers	E1	(Open Collector)

The 1510A will switch from local to remote when the remote line is true (REN) and its listen address is received. The "REMOTE" LED located by the Power Switch will light when the 1510A is in remote.

D. LOCAL MODE

In local, the 1510A front panel is fully operational and the instrument will respond to the Remote message. Whether addressed or not, the 1510A will respond to Clear (DCL), Local Lockout, Clear Lockout/Set Local and the Interface Clear (IFC) messages. When addressed to talk, the 1510A can issue Data messages and the Status Byte message, and whether addressed or not, it can issue the Require Service message. The 1510A ignores all Data messages in the local mode.

The 1510A always switches to local from remote when it receives the Local message (GTL) or the Clear Lockout/Set Local, which sets the REN line false. If not in Local Lockout, the 1510A will switch from remote to local when the Reset button is pressed. However, this will also reset the 1510A and all current data will be lost. If the 1510A is in Local Lockout, the Reset button is inoperative. The 1510A may be reset by issuing the Clear message (DCL or SDC). This puts the 1510A in AC Volts, updates all switches to their current position and clears the status byte.

E. RECEIVING THE DATA MESSAGE (LISTENING)

Table 7 shows the GPIB commands the 1510A will respond to in remote. Although the table is shown in upper-case notation, the 1510A will respond equally to lower-case notation.

The commands are entered the same way they would be on the front panel in local operation. For example, to do AC Volts, Start Inputs and Start Outputs, simply enter the string: "ACSB". If it were desired to have the 1510A start with a Trigger message, the string would change to: "ACTB". Then, upon receiving the Device Trigger message, the inputs and outputs would start. However, once a Device Trigger message is received, the "TB" command is cleared and must be reissued prior to each Device Trigger (GET) command. Another consideration is that since the "SI", "SO" and "SB" commands cause an immediate start, they should not be issued until all other parameters are set. For example; if the string "FRSB01" is sent, and the 1510A is set on "03", the test will reset when "01" is issued because changing the offset during a test causes a reset. However, if the unit was already in "01" it would not reset, because there would be no change. It is also recommended that no command be issued immediately following a "SB" or "SI" command. This is because the GPIB handshake is completed before the start sequence is finished, and the start sequence may clear the next command. For example, in Frequency Response, Manual the following string would move the Vernier up:

"FRMASOUPSI"

However, in the next example, the "UP" command is missed because the start sequence clears it:

"FRMASBUP"

Another alternative that will move the Vernier up would be:

```
OUTPUT 728; "FRMASB"
WAIT 500
OUTPUT 728; "UP"
```

The first example is preferred because it's much faster.

The 1510A ignores ASCII spaces, commas, CR and LF characters unless they appear between the two characters of a command. The following examples are valid command strings: (b = space)

A) "SPF1SO"
B) "SP,F1,SO"
C) "SPbF1bSO"

Table 7. 1510A GPIB Commands - Alpha Order

AC	AC Volts
AT	Attenuator *1
AZ	Azimuth
BL	Read Bottom-Left
BR	Read Bottom-Right
CL	Clear Split
CP	Cursor Position **2
CS	Channel Separation
CV	Clear Reverse
CX	Clear Expand
D2	Second Distortion
D3	Third Distortion
DO	Drop-Out
DN	Down
DR	Display Reference
EX	Expand
F1	Flat-NAB-NAB-NORM-3.0-3.0
F2	Flat-ANSI-JIS-NORM-3.0-3.15
F3	Flat-CCIR/ARM-DIN/ANSI-NORM-3.15-8.0
FD	Freq. Response With D3
FL	Flutter
FR	Frequency Response
FS	Frequency Response with 75 μs
FT	Spot Freq.
IR	Input Reference
LL	Low Sweep Limit
LR	Left & Right
LT	Left
MA	Manual
ML	Maximum Output Level
NR	Service Request Off
NS	Noise
01	-20dB/315Hz
02	-10dB/333Hz
03	0dB/400Hz
04	+10dB/1kHz
OM	Output Monitor
OR	Service Request On
RE	Repeat
RF	Read Reference
RS	Reference Set/Recall
RT	Right
RV	Reverse ***3
SB	Immediate Start Both
SC	Self Check
SI	Immediate Start Input
SL	Split
SN	Single
SO	Immediate Start Output
SP	Speed
ST	Stop
TB	Trigger Start Both
TI	Trigger Start Input
TL	Read Top-Left
TO	Trigger Start Output
TR	Read Top-Right
UP	Up
W1	Weighted-NAB-NAB-FAST-3.0-3.0
W2	Weighted-ANSI-JIS-FAST-3.0-3.15
W3	Weighted-CCIR/ARM-DIN/ANSI-FAST-3.15-8.0

*1 Requires additional information, i.e., AT15.5dB

**2 Requires additional information, i.e., CP10.0kHz

***3 The "REVERSED" LED on the front panel will <u>NOT</u> glow when the 1510A is placed in Data Reverse in remote, <u>unless</u> the button is pushed in too.

The following examples are not valid:

A) "SbPF1SO"
B) "S,PF1SO"

The non-valid examples will be ignored by the 1510A and status byte 97 will be sent. (See Paragraph 3-17G)

After issuing a start command, the user must either wait for the status byte to be sent, if applicable, telling that the sequence is done, or allow enough time for the measurement to be made before stopping the test. The following status bytes indicate a finished sequence:

BYTE	MEANING
65	Data Ready - sent only in Single Sweep when the input is done.
66	Record Completed - sent only in Single Sweep when the output is done. (CRT will show "RECORD COMPLETED".)

When making manual measurements or measurements that do not sweep, like AC Volts, the user must allow enough time for the data to settle before reading it.

The cursor may be positioned randomly in all tests except for the Azimuth, Drop-Out and Speed tests. The following examples will move the cursor in Channel Separation:

A) "CP500HZ"
B) "CP1.00kHz"
C) "CP20.0kHz"

The characters after "CP" <u>must</u> appear, except for spaces, exactly as they do in the lower-right corner of the CRT for each test. Spaces are omitted. In some cases, entering a bad cursor string will cause status byte 97 to be sent and the cursor will not move. In other cases, the cursor may go to an erroneous position, but can be positioned correctly by issuing the correct string.

1510A GPIB ATTENUATOR

Use like the Cursor; i.e. "CP10.0 kHz" <u>"AT15.5dB"</u>

Generic Format: "AT(X)Y.Z DB"

1. Where X, Y & Z can be 0 thru 9 and X may be omitted.
2. AT & DB may be lower case

Examples: "AT79.9dB"
"AT0.0dB"
"AT00.0dB"
"AT7.4dB"

The attenuator has a total range of 79.9 dB. A command of "AT0.0dB" will set the 1510A at full output, 10 dBm.

A command of "AT10.0dB" will set the 1510A at 0 dBm.

(The command for the attenuator is in attenuation and not dBm.)

Both the -20, -40 & verniers are controlled in this one command.

The maximum is "AT79.9dB" = -69.9 dBm

To move the cursor to the left in Drop-Out, Azimuth or Speed, the data must be entered for its current position, then it will move to the left one window. For example, the following instruction on the HP85A will move the cursor down one window:

```
ENTER 728; B$
```

<u>IEEE P728 Format Capability Identification Codes:</u>

Program Message Examples:	Format:	Capability Codes:
"D3,CP-10DB,LL,SB"	NDR1	PM1
"FR,CP10.0kHz,SB"	NDR2	PM1

F. SENDING THE DATA MESSAGE (TALKING)

Before addressing the 1510A to talk and send data, a "talk command" should be issued. These commands, shown in Table 7 are:

"RF"	read reference
"TL"	read top-left
"TR"	read top-right
"BL"	read bottom-left
"BR"	read bottom-right

If no talk command is issued and the 1510A receives its talk address, the 1510A will send Status Byte 100 and assume the command of "RF".

To read data from any test, issue the command that describes the location of the data you want to read. (For Azimuth data, use "BR".)

The following example, which is a typical CRT display is "FD", both channels, shows what data would be sent for each command. Assume a reference of 500 mV.

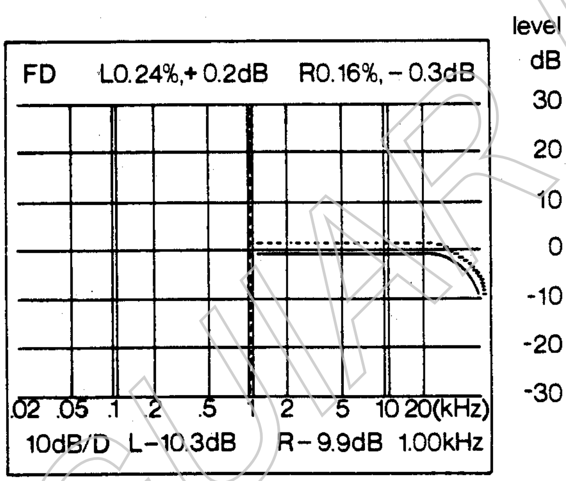


Figure 11

"RF"	500mV CR (LF*EOI)
"TL"	0.24%,+0.2dB CR (LF*EOI)
"TR"	0.16%,-0.3dB CR (LF*EOI)
"BL"	-10.3dB,1.00kHz CR (LF*EOI)
"BR"	-9.9dB,1.00kHz CR (LF*EOI)

EOI, END or IDENTIFY, is sent with the LF at the end of the Data message in Manual, in AC Volts, in NS or FL when reading composite, in FD when reading D3 and when reading the reference In Single or Repeat, EOI is not sent with the LF until the data is read at the Low Sweep Limit. When reading data in Single or Repeat, the Cursor should be placed at the first point to be read. When that point is read, the Cursor will automatically move to the left one point, until it reaches the Low Sweep Limit.

In the following example, a frequency response curve was plotted from 40.0 kHz to 1.00 kHz. The Low Sweep Limit is 1.00 kHz. To read the data from 40.0 kHz to 1.00 kHz, the cursor is first placed at 40.0 kHz, then the data is read for 60 points:

```
10  OUTPUT 728; "CP40.0kHz"
20  LET A = 60
30  ENTER 728; B$
40  DISP B$
50  LET A = A - 1
60  IF A ≠ 0 THEN 30
70  END
```

The above example does not make use of the EOI being sent at the last point. However, the loop pattern of decrementing A doesn't need to be used if the Enter statement is terminated with EOI.

The data could also be randomly read by positioning the cursor somewhere, using the "CP" command, before each ENTER statement.

When reading data that was being updated at the time the Stop command was sent, like AC Volts, there is a chance that the data on the CRT and the data sent to the GPIB won't be the same. This is normal. It is due to the data buffer being updated with a new reading, but not the CRT.

IEEE P728 Format Capability Identification Codes:

Data Message Examples:	Format	Capability Codes:
+0.3dB,4.00kHzCR(LF*EOI)	NDR2	(,)END

The following sample program on an HP85A computer places the 1510A in remote, goes to AC Volts, Left, Single and Start Both. After waiting two seconds, it sets the Reference, goes to Frequency Response, places the Cursor at 10.0 kHz, sets the Low Sweep Limit and Starts Both. Upon receiving the "data ready" status byte, the read command of Bottom Left is sent, the Cursor is put at 40.0 kHz and the display is moved Up three times and Down three times. Then six data points are entered and displayed starting at 40.0 kHz. Then the 1510A is returned to local control.

```
 30  ON INTR 7 GOTO 260
 40  ENABLE INTR 7;8
 50  REMOTE 728
 80  OUTPUT 728 ; "ACLTSNSB"
 90  WAIT 2000
180  OUTPUT 728 ;"RSFRCP10.0KHZLL
     SB"
190  SET TIMEOUT 7;30000
200  ON TIMEOUT 7 GOTO 230
220  GOTO 220 ! LOOP
230  DISP "WOOPS!"
240  GOTO 400
260  S=SPOLL(728)
270  IF BIT (S,5) = 1 THEN GOTO 230
280  IF BIT(S,0) ≠ 1 THEN GOTO 230
290  STATUS 7,1 ; A
330  OUTPUT 728 ;"BLCP40.0KHZUPUP
     UPDNDNDN"
350  LET A=6
360  ENTER 728 ; B$
370  DISP B$
380  LET A=A-1
390  IF A ≠ 0 THEN 360
400  LOCAL 728
410  END
```

The resultant display on the computer is:

```
+0.3dB,40.0kHz
+0.3dB,37.0kHz
+0.3dB,35.0kHz
+0.3dB,33.0kHz
+0.3dB,31.0kHz
+0.3dB,29.0kHz
```

G. SENDING THE STATUS BYTE MESSAGE (SERIAL POLLING)

Table 8 shows the 1510A Status Byte message coding for the Serial Poll Function.

The sending of the status byte may be suppressed by issuing the command "NR". It may be resumed by the command "OR". EOI is always sent with the status byte. In most cases, the 1510A shows on the CRT why the status byte was sent. If Speed, for example, is set in Manual Sweep, status byte 112 will be sent and the 1510A CRT will read "MANUAL SWEEP NOT VALID".

H. TUTORIAL ON THE GPIB/1510A

1. What is the GPIB?

Quite some years ago, it was decided that there was a need for a general purpose interface bus that would allow different kinds of devices to communicate with each other. Even though these devices may be quite different from each other in what function they perform, they can still communicate with each other. Some

Table 8. 1510A GPIB Status Bytes

BIT:	7	6	5	4	3	2	1	0	CONDITION:	HEX/DECIMAL CODE:
	0	0	0	0	0	0	0	0	NO REQUEST	00/00
	0	1	0	0	0	0	0	1	DATA READY	41/65
NORMAL	0	1	0	0	0	0	1	0	RECORD COMPLETED	42/66
	0	1	0	0	0	1	0	0	I'M OK, YOU'RE OK	44/68
	0	1	1	0	0	0	0	1	BAD GPIB CODE RCV'D	61/97
	0	1	1	0	0	0	1	0	NO LISTENER ON BUS	62/98
ABNORMAL	0	1	1	0	0	1	0	0	NO TALK COMMAND, ASSUMES "RF"	64/100
	0	1	1	0	1	0	0	0	FAILURE MODE	68/104
	0	1	1	1	0	0	0	0	INSTRUMENT ERROR: 1) NO REFERENCE 2) NO CHANNEL SELECTED 3) NO STANDARDS 4) L & R NOT VALID 5) MANUAL NOT VALID 6) REPEAT NOT VALID 7) START INPUTS & OUTPUTS TOGETHER 8) I & O NOT VALID	70/112

devices may only be able to send data, like a tape reader. This type of device is known as a "Talker". Some devices may only be able to receive data, like a signal generator. This type of device is known as a "Listener". Some devices may be able to both talk and listen, like a digital voltmeter. Of course, some device may have to oversee these talkers and listeners while they are communicating. This type of device is called a "Controller".

The bus itself has many names. The three official names are:

1. IEEE 488-1978

2. ANSI MC1.1

3. IEC 625-1

These are all the same, except that the IEC bus uses a different connector. Adaptors for the IEC cable are readily available. Except for the IEC cable, the 1510A will work with any of the above names. Some common bus names used are:

1. IEEE-488

2. GPIB

3. HP-IB

In order for different instrument designers to be able to make their devices work on the bus, certain rules had to be made by the people who wrote the standard for the bus. The main part of these rules is called the Interface Functions. These define the rules of bus communications. The Interface Functions are described briefly below. If the reader desires a complete understanding of the bus, he should consult the document: "IEEE Standard Digital Interface for Programmable Instrumentation", available from the IEEE in New York City. However, <u>no</u> knowledge of the Interface Functions <u>is</u> required for programming the 1510A, and the following descriptions should be read with this in mind.

NAME: MNEMONIC:

Talker and Extended Talker — T, TE
This function describes how a device will talk on the bus.

Listener and Extended Listener — L, LE
This function describes how a device will listen on the bus.

Source Handshake — SH
This function describes how a talker can send its data. This is part of the Talker function.

Acceptor Handshake — AH
This function describes how a listener can receive data. This is part of the Listener function.

Remote/Local — RL
This function describes how a device can select between two modes of inputing information. Local means inputting through the devices' front panel and remote means inputting over the bus.

Service Request — SR
This function describes how a device can tell the controller that it needs service. An example of needing service would be a devices' data being ready to send to a listener. An important feature is that the device signals the controller, or interrupts it, when it needs service. Generally, when the controller is interrupted in this way, it performs a serial poll, which is described later.

Parallel Poll — PP
This function describes how a device tells a controller it needs service, when asked by the controller. It cannot signal the controller like in Service Request.

Device Clear — DC
This function describes how a device can be reset to a pre-defined condition. This is the same as pushing the RESET button on the 1510A.

Device Trigger — DT
This function describes how a device can have its basic operation started by the bus.

Controller — C
This function describes how a controller will operate the bus.

Drivers — E
This describes the type of bus drivers used by a device. A bus driver is usually an integrated circuit that provides the proper voltages and currents to supply power to the bus cable.

The bus itself consists of twenty-four lines. Eight lines are the data bus, eight lines are grounds, five lines are bus management lines and three lines are handshake lines. These are described as follows. (Again, knowledge of the following is not necessary to program the 1510A but may give a clearer understanding of the bus.)

The Data Bus — DI01-DI08
The data bus is an eight-bit bus used for sending data between talkers and listeners and also for the controller to send some commands. The bus is bit-parallel and byte-serial.

Handshake Lines — DAV, NRFD, NDAC
These three lines make sure that data is sent and received properly. DAV, data valid, is used by the talker to tell the listeners that the data on the data bus is valid. NRFD, not ready for data, is used by listeners to tell the talker whether or not they are ready to listen. NDAC, not data accepted, is used by listeners to tell the talker whether or not they have received the data. (The "not" in NRFD and NDAC indicates that the signal's logic is inverted.)

Management Lines ATN, IFC, SRQ, REN, EOI
These lines manage transactions on the bus. ATN, attention, is a line used by the controller that tells all listeners

if the data bus has data from another device or a command from the controller. IFC, interface clear, is a command line used by the controller to clear all activity on the bus. SRQ, service request, is a line used by devices to tell the controller they need service. REN, remote enable, is a line used by the controller to enable all devices to go into the remote mode of inputting data. EOI, end or identify, is a line shared by devices and the controller. If the controller sets this line, along with ATN, it wants to do a parallel poll, so it tells all devices to "identify". If a device sets this line, it's telling the controller that it's finished sending data, so it sends "end". The controller can also send "end" by not setting ATN and setting EOI.

2. What can the 1510A do on the GPIB?

The 1510A can both talk and listen, and can also respond to most controller commands. It cannot act as a controller. Before going any further, it is necessary to discuss addresses. In order to know "who's who" on the bus, each device must have its own address. This can be any number between 0 and 30, inclusive. Addresses are used much like they are in the mail. If you want to send a letter to someone, you need to know their address. Address switches are usually found on the rear panel of a device, as on the 1510A. The procedure for setting the 1510A address is found on page 57.

This same page shows the Interface Functions that the 1510A can do. The functions were described with two letters, the mnemonic, like "SH" for source handshake. In table 6 this appears as "SH1". The number after the two letters describes the degree to which the function is implemented. This is necesary because the standard describes subsets to these functions. However, except for Talker and Listener, the 1510A either fully implements these functions or omits them. These conditions are shown in the third column in Table 6. What these functions mean in terms of what you can actually do with the 1510A is described as follows.

Talker and Extended Talker T,TE

Service Request SR

If we want the 1510A to talk to the controller, which can act as a listener, we need to tell the 1510A to send data to the controller. Usually, the controller can do this with just a few statements. Let's analyze a typical statement from a Hewlett-Packard HP 85 desk top computer:

```
ENTER 728 ; B $
```

The "ENTER" statement is used to tell the controller that a device is to talk to it. The "7" in the statement is the interface select code of the interface unit attached to the rear of the HP85. The "28" in the statement is the address of the 1510A. "B$" means that the data is to be entered into a storage area in the computer called "B$". The "B" designates a register. But a register only contains a single byte. In order to lengthen it to contain many bytes, the "$" sign is placed after the "B". This combination is usually called a "string variable". (See Paragraph 3, page 67, for examples.) Therefore, device 28 on interface 7 is going to talk to the controller. The device, in this case, is the 1510A.

Another way the 1510A can talk is in response to a Serial Poll. Let's see what a serial poll is. When the 1510A sets its Service Request, SRQ line, this tells the controller that the 1510A needs service. In order to know the nature of the service needed, the 1510A must send a Status Byte to the controller when the controller does a serial poll, in response to the SRQ line being set. The Status Byte is a single eight-bit word sent on the data bus. It is coded to mean specific things. See table 8, page 63. Most controllers do not respond to the SRQ line automatically, nor do they do a serial poll automatically. To do a serial poll of the 1510A on the HP85, you would type:

SPOLL (728)

The "728" means the same thing as in the ENTER statement. (See Part 3 for examples.) Thus, a serial poll is the method of obtaining a devices' status byte. Since there could be many devices on the bus, but there is only one SRQ line, it is necessary to serial poll <u>every</u> device on the bus each time the SRQ line is set. Extended Talker is a method of extending a devices's address. Since this was not used on the 1510A, it will not be discussed.

<u>Listener and Extended Listener L,LE</u>

If we want to send data or commands to the 1510A, then it must listen to the talker, which is usually the controller. On most controllers, this is done with just a few statements. Let's look at an example on the HP85:

OUTPUT 728 ; "ACSB"

Again, the "728" means the same as in the ENTER statement. In this example, the controller would output the command letters "ACSB", taking care of all handshaking and other necessary signals. See Table 7 for a list of 1510A commands. Extended Listener was not used on the 1510A and will not be discussed.

<u>Remote/Local RL</u>

There are several controller commands that come under the RL function. Let's look at them as they would appear on an HP85.

a. REMOTE 7 or REMOTE 728

Typing "REMOTE 7" sets the Remote Enable, REN, line on interface 7, but does not put any devices in remote. Typing "REMOTE 728" also sets the REN line on interface 7 but also puts the 1510A in the remote condition. In the remote condition, commands can only be entered over the bus and most of the buttons on the front panel are inoperative.

b. LOCAL 7 or LOCAL 728

Typing "LOCAL 7" resets the REN line on interface 7. This makes any devices on that interface that are in remote go back to local. Typing "LOCAL 728" will make only the 1510A go back to local if it was in remote. No other device is affected.

c. LOCAL LOCKOUT 7

Typing "LOCAL LOCKOUT 7" prevents any devices on interface 7 from being returned to local from remote when the "LOCAL" button on a device is pressed. On the 1510A, this is the RESET button. This statement can only be cleared by typing "LOCAL 7".

<u>Device Clear DC</u>

Normally, the 1510A is reset, or cleared, by pushing the RESET button. This can also be done over the bus by typing on the HP85:

CLEAR 7 or CLEAR 728

Typing "CLEAR 7" will clear every device on interface 7. Typing "Clear 728" will clear only the 1510A.

Device Trigger — DT

If it is necessary to start several devices doing their measurements at the same time, then the trigger function can be used. Let's see how to use this with the 1510A. On Table 7 it can be seen that there are three "trigger" commands; TB, TI and TO. These do the same thing as the regular start commands, SB, SI, and SO, with one important difference. Normally, to do AC Volts, start input, one would type on the HP85:

```
OUTPUT 728 ; "ACSI"
```

This would make the inputs start immediately. But if one types:

```
OUTPUT 728 ; "ACTI"
```

the 1510A would go to AC Volts but the inputs would not start until the controller sent the trigger command:

```
TRIGGER 7 or TRIGGER 728
```

Typing "TRIGGER 7" would trigger all devices on interface 7. Typing "TRIGGER 728" would only trigger the 1510A.

Parallel Poll — PP

Controller — C

The 1510A cannot respond to a parallel poll nor can it act as a controller. Therefore, these functions will not be discussed.

This has been an extremely short description of the GPIB. The next paragraph shows programming examples for the 1510A. Most controllers, like the HP85 or the Apple II, have large manuals with them that explain in more detail how to control the bus. These should be used! Also, the bus itself is much more complex than shown in this document. For a complete understanding of the bus, one should consult the standard itself, available from IEEE, ANSI or IEC. There are also numerous books written about the bus by Hewlett-Packard, Tektronix and others.

3. Programming Examples

The following examples are to help explain typical GPIB programs on an HP85 computer. Programs on an Apple II would be similar. These programs are all written in BASIC, Beginner's All-purpose Symbolic Instruction Code. The more you know about BASIC, the better. Use the manuals that come with your computer for this.

Let's completely analyze the program shown on page 62 shown again here for convenience.

```
 30 ON INTR 7 GOTO 260
 40 ENABLE INTR 7;8
 50 REMOTE 728
 80 OUTPUT 728 ; "ACLTSNSB"
 90 WAIT 2000
180 OUTPUT 728 ;"RSFRCP10.OKHZLL
    SB"
190 SET TIMEOUT 7;30000
200 ON TIMEOUT 7 GOTO 230
220 GOTO 220 ! LOOP
230 DISP "WOOPS!"
240 GOTO 400
260 S=SPOLL(728)
270 IF BIT (S,5) = 1 THEN GOTO 230
280 IF BIT(S,0) ≠ 1 THEN GOTO 230
290 STATUS 7,1 ; A
330 OUTPUT 728;
     "BLCP40.OKHZUPUPUPDNDNDN"
350 LET A=6
360 ENTER 728 ; B$
370 DISP B$
380 LET A=A-1
390 IF A ≠ 0 THEN 360
400 LOCAL 728
410 END
```

Line 30 - ON INTR 7 GOTO 260.

This tells the computer that when it detects an interrupt, INTR, on interface 7, like the SRQ line being set, the program should jump to line 260 from wherever it is in the program. There are, however, other types of interrupts besides the SRQ, so we need a statement to tell the computer which one to respond to. Let's move to Line 40.

Line 40 - ENABLE INTR 7 ; 8

This enables the computer to respond to a certain interrupt on interface 7. The "8" in this statement tells which interrupt, in this case, the SRQ line.

Line 50 - REMOTE 728

This sets the REN line true on interface 7 and puts the 1510A in remote. From now on, the front panel buttons will be inoperative and commands can only be issued over the bus, unless the RESET button on the 1510A is pressed. If this happened, the 1510A would reset and return to local control. The Local Lockout Command would prohibit the 1510A from returning to local.

Line 80 - OUTPUT 728 ; "ACLTSNSB"

This statement outputs the commands "AC LT SN SB" to the 1510A, which is on interface 7 and has an address of 28. This statement, along with the ENTER statement, is the key to programming the 1510A. As seen in Table 7 these commands place the 1510A in AC Volts, Left Channel, Single Sweep, Start Inputs and Outputs.

Line 90 - WAIT 2000

The HP85 can wait in the program to allow the 1510A's measurement, in this case AC Volts, to settle out. The command is: WAIT X ms. So this line makes the controller wait 2,000 ms or 2 seconds. If this statement were left out of the program, then the controller would continue to line 180 and try to set the Reference before the measurement had settled out, thus making the Reference invalid.

Line 180 - OUTPUT 728; "RSFRCP10.OKHZLLSB"

This statement outputs the commands inside the quotation marks, called a command string, to the 1510A. Commands, as seen on Table 7 are always in groups of two letters, except for the Cursor and Attenuator Position. Let's see what this command string does in detail:

RS - sets the Reference on the 1510A. (Recall that the 1510A has already been put in AC Volts and has had its inputs and outputs running for 2 seconds.)

FR- sets the 1510A to Frequency Response.

CP10.OKHZ - sets the Cursor to 10.0 kHz.

LL - sets the Low Sweep Limit.

SB - starts inputs and outputs, which is called "start both".

At this point, the 1510A is doing a single Frequency Response sweep of the Left Channel from 40.0 kHz to 10.0 kHz. How is it going to tell the computer when it has finished the test? We could use the WAIT statement again, making the computer wait a long enough time for the sweep to finish and then reading the data. However, figuring out the sweep times for tests is very time consuming. Wouldn't it be better if the 1510A could tell the controller that the sweep had ended? It can, using the SRQ line and interrupt the controller. (This action could be inhibited by using the command "NR", which turns off the Service Request Function.)

Let's examine the lines between lines 180 and 260. Later on, the 1510A is going to be talking to the controller. What would happen if the 1510A stopped sending data when it was talking? The controller would wait forever for more data; it would get "hung-up". As a precaution against such a failure, we can set a timer that will abort the program if it should hang-up. Lines 190 and 200 set this timer in a similar way to setting the interrupt in lines 30 and 40. The timer is set on interface 7 for 30 seconds and after that time, the program will jump to line 230. Line 230 would print "WOOPS!" on the display. Line 240 would cause the program to jump to line 400, which would return the 1510A to local control and then stop the program with line 410.

Assuming this problem will not occur, let's continue. After setting this emergency timer on lines 190 and 200, the program continues to line 220. Line 220 reads "GOTO 220 ! LOOP". A way of writing a comment on a line, that does not affect the computer, is to type the "!" character followed by the comment. So the actual command in line 220 is "GOTO 220". Why should a line jump to itself? This is a method of waiting, without specifying a time. This statement will "LOOP" forever or until an SRQ interrupt is generated. At this time, then, the controller is waiting for an SRQ interrupt.

Upon receiving the SRQ interrupt, the program jumps to line 260, as told to by the command in line 30. Now the controller knows that an interrupt has been issued by the 1510A, but it does not know why. In order to know why, the controller must get the status byte by doing a Serial Poll. As shown in table 8, the status byte can mean many different things. So, we must not only get the status byte, but we must also examine it to see the nature of the service request. Line 260, S=SPOLL(728), does the serial poll of the device on interface 7 with an address of 28, which is the 1510A in this case. The status byte is stored in memory under the name of "S". (A common name for "S" would be a "register".) Line 270 and 280 examine the status byte. As stated in Part 1, the status byte is sent over the data bus, which has eight lines in it. This means that the status byte is made up of eight lines or bits. These bits, in combination with each other, indicate different conditions within the 1510A. In order to make sure that the "Data Ready" status byte was sent during the serial poll, it is necessary to make sure bit 0 is at a high level and bit 5 is at a low level. (Bit 6 always copies the SRQ line, so for any request, it is always high.) In line 270, we examine bit 5 of register S, and if it is equal to one, or high, the program would print "WOOPS!" and end, as before. If bit 5 is equal to zero, or low, the program continues to line 280. At line 280, if bit 0 is not equal to one, then the program would end as above. If bit 0 is equal to one, the program continues. Thus, we now know that the status byte is showing "Data Ready". Line 290 reads the computer's status register 1 and puts the number in register A. This is of no use to us but is required to enable the computer to recognize future interrupts.

At this point, we know that the 1510A has completed its single sweep and data is ready to read. As stated in the Operator's Manual, two things must be done before reading the data. First, the location of the data on the CRT to be read must be designated and second, the cursor must be placed at the first data point on the graph that is to be read. In Line 330, we output to the 1510A these two parameters. "BL" tells the 1510A that the data to be read is the left-channel data on the bottom line of the CRT. CP40.0KHZ places the cursor at 40.0 kHz on the graph, so 40.0 kHz will be the first data point entered into the controller. The "UPUPUPDNDNDN" commands in the line are only to show how fast the display can respond to commands. If you watch the display during the execution of this command string, you'll see the graph rapidly move up three times and down three times.

Lines 350 to 390 inclusive show a typical way of transferring data from the 1510A to the controller. Let's look at each line. Line 350 loads register A with the value of 6. This tells how many data points will be entered, starting at the Cursor position. The number of points to be entered is determined by the operator. This number can be found by counting how many points you want, using the cursor switch. Line 360 is the most complex and important line in the program. As stated in Part 2, the ENTER statement will enter the data of device 28 on interface 7 and store it in the storage area called "B$". Two questions arise here; what data is entered and how does the computer know when the data is finished being entered?

The 1510A automatically sends the data in the format shown on page 61 under figure 11. This format cannot be changed. The controller knows the 1510A is done sending data for that one data point because the 1510A sends two "invisible" characters, called a "carriage return" and a "line feed". These are not part of the data, but rather tell the HP85 to terminate the ENTER statement. Other termination methods can be used, but this is the easiest. See your computer's programming manual for more information on the ENTER statement.

Line 370 simply displays on the CRT whatever is in "B$", which is the data.

Line 380 now decrements the A register, which was given a value of 6 in line 350. Now its value is 5.

Line 390 says that as long as the value in the A register is greater than zero, keep jumping back to line 360, but if A is equal to zero, continue on. Since A is now equal to 5, the program will jump back to line 360 to get more data and continue doing so, each time decreasing A by one. This is how we count the six data points. This is known as "looping". See page 61.

After the six points are entered and displayed, the program continues to line 400. Line 400 places the 1510A back to local control. The program then stops at line 410. All BASIC programs need the END statement at the last line.

4. System Set-up

Up to 15 instruments can be connected on the bus, including the controller. However, the total length of all the cables used must be less than or equal to 2 meters times the number of devices connected to the bus, up to a maximum of 20 meters. Caution should be taken if individual cable length exceeds 4 meters. Not all devices must have their power on, but generally at least two-thirds of them should. Either of the two methods shown in Figure 12 can be used to connect up a system.

3-18 DROP-OUT TEST

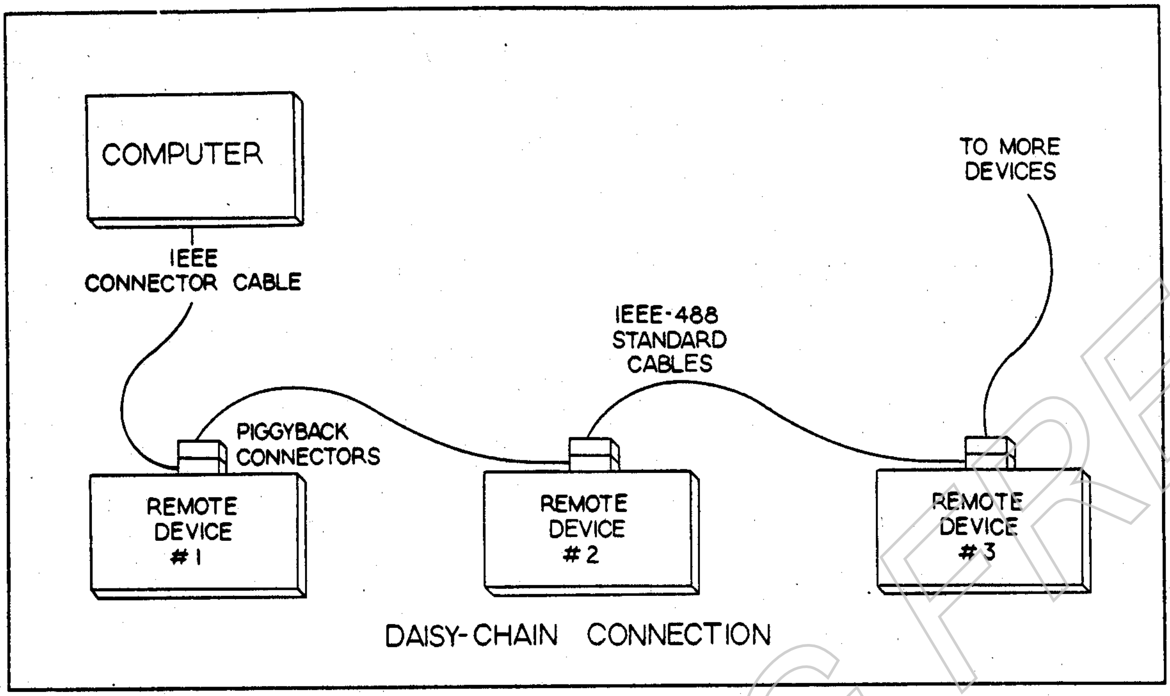
A. GENERAL INFORMATION

The following is a summation of the IEC 94, Part 5, 1981 specification on drop-out annoyance testing for magnetic tape recorders as used by Sound Technology.

B. SOUND TECHNOLOGY DROP-OUT TEST

The 1510A drop-out test complies with the IEC specification. This test will give the 1510A operator the total number of drop-outs for each 20 second period of time for a maximum of 50 periods (1000 seconds or 16 minutes and 40 seconds). Also presented on the display, is the percentage of 20 second periods in each of four drop-out annoyance categories. With the displayed information, the location of the drop-outs on the tape can be found, and the degree of annoyance these drop-outs are to the listener is also available.

If for example, the 1510A display shows that there are drop-outs during the first 60 seconds of a reel of tape, and



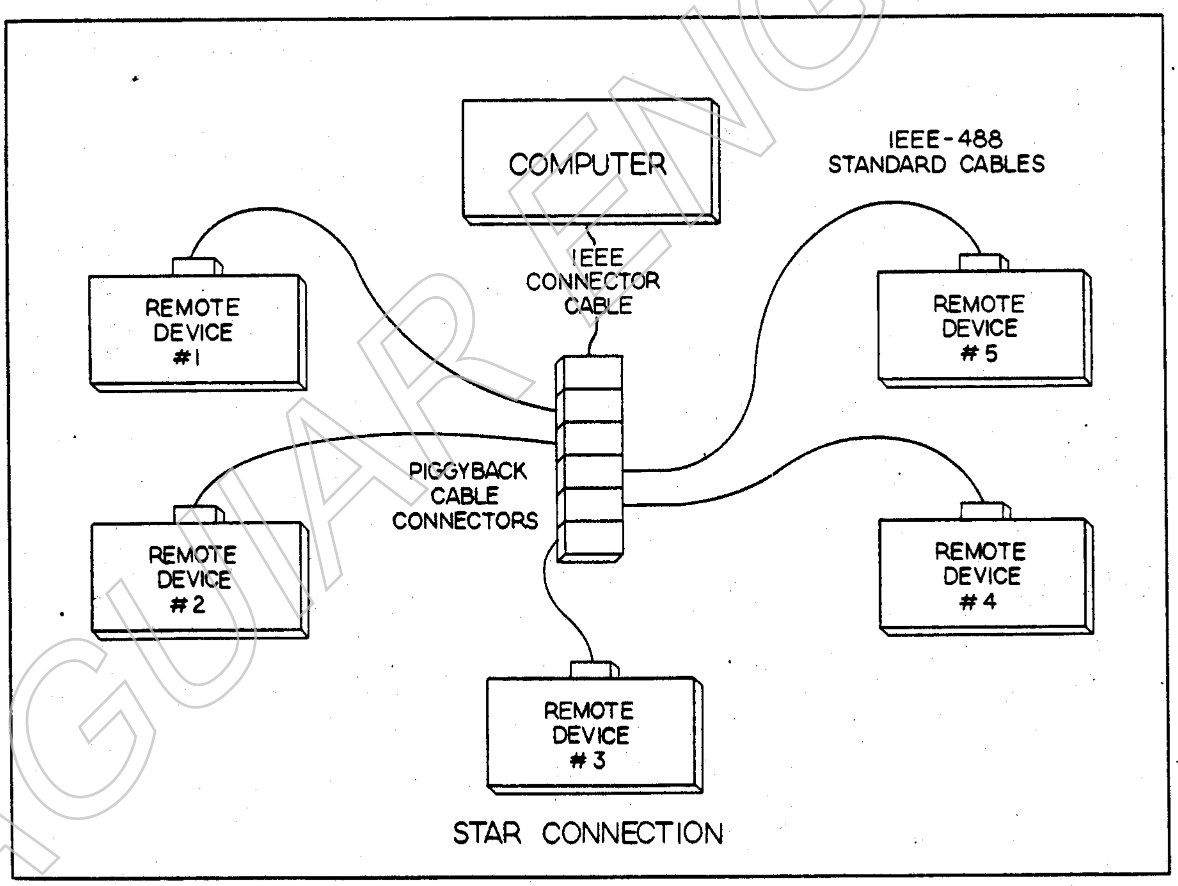


Figure 12. GPIB System Set-Up

Table 9. h_1 - Isolated Drop-out Values

Depth in dB / Duration in ms	> 4.0	> 4.9	> 5.5	> 6.2	> 7.1	> 8.0	> 8.9	> 9.9	> 11.4	> 12.8	> 14.4	> 16.5	> 20.0	> 26.0
10-20							2	2	3	3	4	4	5	6
20-50			2	3	4	5	5	6	7	8	9	10	11	12
50-1000	2	3	4	5	6	7	8	9	10	11	12	12	12	12

these drop-outs are mostly in category one, the operator might make one of the following decisions. Use the tape as is because the drop-outs are acceptable; use a different reel of tape; or remove the first 60 seconds of tape from the reel. By way of definition, a drop-out is a momentary reduction of the reproduced signal level with the reduction of level and duration as defined in Table 9. h_1 in this table is defined as the Isolated Drop-out Value and its use will be described later. Any h_1 value of 2 and greater is defined as a drop-out. For example, if the signal level is reduced by more than 8.9 dB but less than 9.9 dB for 15 milliseconds, then a drop-out will be displayed. If the duration was less than 10 milliseconds, a drop-out would not be indicated.

The drop-out annoyance values are defined as follows:

if hp = drop-out annoyance

and $hp = h_1 + h_2 + h_3$

where:

h_1 = Isolated drop-out value.

This is the value found in Table 9 which is the drop-out depth versus the drop-out time duration. Any drop-out that meets the Table 9 requirements is assigned the value in this table.

h_2 = Accumulation marks.

Any drop-out, after the first drop-out for each 20 second period, with the value of $h \leq 4$ will add one mark to the h_2 value.

h_3 = Cluster marks.

The number of marks depends upon the number of drop-outs for each one second period of time. The following table will assign these marks.

Number of Drop-outs for each One Second Period	Marks
2	2
3	3
4 or more	4

Then, after each drop-out period of 20 seconds, the total marks are added together and stored in memory according to which category they belong. Also, the total number of drop-outs for this period are displayed on the graph.

The four categories are:

Category Number	hp value for 20 second period
1	$2 \leq hp \leq 4$
2	$5 \leq hp \leq 8$
3	$9 \leq hp \leq 12$
4	$13 \leq hp$

At the end of the test or when the STOP button is pressed, the categories are displayed at the top of the CRT in percentage of the total number of 20 second periods.

For example, if a particular drop-out test on a tape was run for the full 50 periods the following notation could appear at the top of the display at the end of this test.

C1:50% C2:10% C3:0% C4:2%

The C1:50% indicates that 50% of the 50 periods have drop-outs with h values between 2 and 4. C2:10% indicates that 10% of the periods have drop-outs with h values of between 5 and 8 and so forth.

In this example there are 25 periods (20 seconds) that have catagory 1 drop-out value, 5 periods with catagory 2 drop-out value, no periods with catagory 3 drop-out values and 1 period with a catagory 4 drop-out value. The catagory percentages are figured as follows:

Category 1

25/50 X 100 = 50% of hp values

Category 2

5/50 X 100 = 10% of hp values

Category 3

0% of hp values

Category 4

1/50 X 100 = 2% of hp values

Notice in this example that only 62% of the 50 periods have drop-outs that fit into any one of the four categories.

SECTION 4

MAINTENANCE

CAUTION: Do not attempt to repair any fault inside the 1510A. Specialized test equipment and procedures are required to obtain the specified performance. Also, certain components in the 1510A are subject to damage by electrostatic voltages which can occur during handling or probing.

IMPORTANT: Do not operate the 1510A from a 2-wire, ungrounded power system or through a 3-prong to 2-prong adapter.

IMPORTANT: The push button switches are permanently lubricated. Application of any lubricant or contact cleaner will shorten their operational life.

4-1 PERIODIC MAINTENANCE

The cooling fan filter screen requires periodic cleaning. When the screen appears dirty, remove for cleaning by pulling out the central portion of the black plastic grill. Do no remove the four screws at the corners of the grill.

4-2 FAILURE IN SELF-CHECK MODE

If during the SELF CHECK mode, a legend such as "FAILURE MODE C" appears on the display screen, the following items should be checked:

A. Is output level set to 2.0 V? (use FREQ RESP AND OUTPUT MONITOR buttons to set voltage level.)

B. Are the test leads disconnected from INPUTS and OUTPUTS?

C. Are all fuses good?

D. Is the rear panel power input connector PC board installed properly?

E. Is the 1510A grounded through the 3-wire power cable and plug to a proper and reliable earth ground?

After the items noted above have been checked and corrected, as required, press the SELF CHECK button.

If the same or another Failure Mode legend appears, call Customer Service at Sound Technology (408) 378-6540 for assistance in correcting the problem. Specify the 1510A serial number when calling.

4-3 FAILURE AT POWER TURN-ON

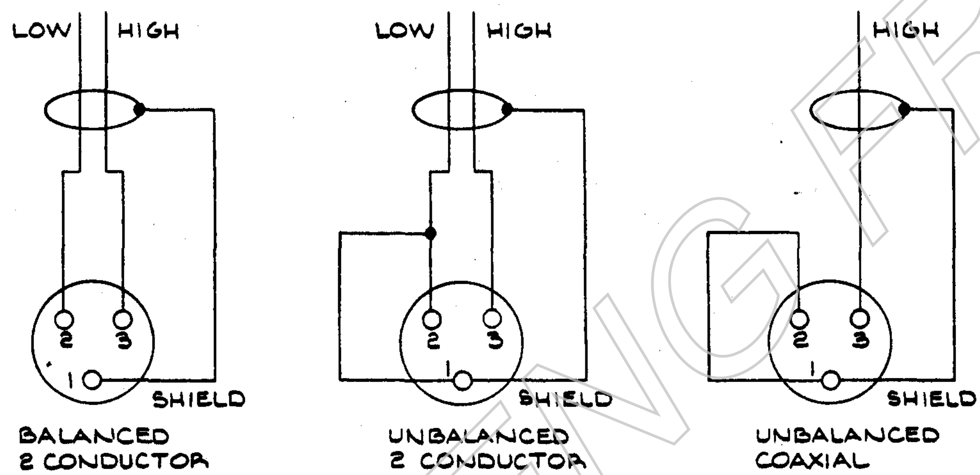
If a legend such as "ERROR CODE 0 E" appears on the display when power is turned on, contact Sound Technology Customer Service.

Addendum #1

Connector and Cable Connections

The following figure identifies the various connections that can be made when connecting the outputs and the inputs of the 1510A.

In the 1510A, there is no high or low, however, for consistency the convention of having high on pin three and low on pin two is followed.



1500/1510 Operators Manual
Addendum #2
MOL Test changes (see page 15)

The MOL test has been modified so that during the <u>active test state</u>, the measured output level of the tape recorder in dBm is displayed at the top of the display. This will allow the operator to monitor the output level to determine the saturation level. This level is the point where the output ceases to increase even though the input level has been increased. The graph on the display is the compression ratio of the unit under test. Saturation is also the point that the compression curve is rolling off at a 45 degree angle. This point can be difficult to measure, because in many cases the saturation curve has a low Q characteristic. (The output level of the tape recorder will change very little with a large input level change.)

The following method can be used to find the saturation level. Run the MOL test in single sweep mode at the desired frequency. After the sweep is finished find the portion of the curve that the compression changes about 5dB when the input (horizontal axis) of the recorder changes by 5dB. Note that the horizontal axis is the input level and the vertical axis is the ratio of the delta output to the delta input of the tape recorder. By going to the MANUAL mode at the correct frequency, move the cursor to this area of the curve. Find the maximum output level by moving the cursor and observing the dBm reading at the top of the display. This will be the maximum output level that the unit under test can generate and is the saturation level.

The following should help to understand this test.

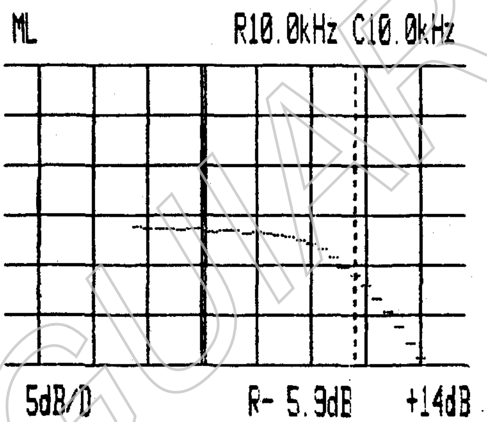


Figure #1. This is the 1500A/1510A display at the end of the MOL sweep test. The curve was run at 10KHz.

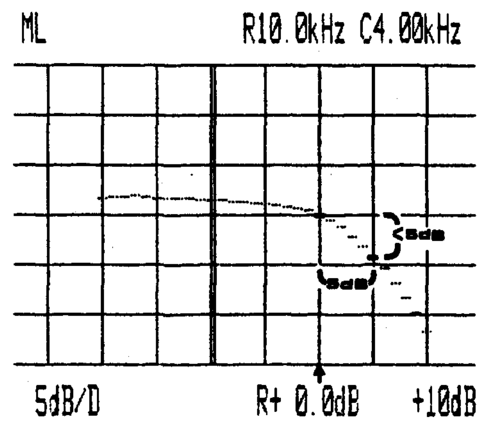


Figure #2. The cursor was moved from +14dB to +10dB (arrow points to the cursor position). The VERT REF - DISPLAY button was pressed so that the vertical axis (compression) can be easily observed. The compression was less than 5dB.

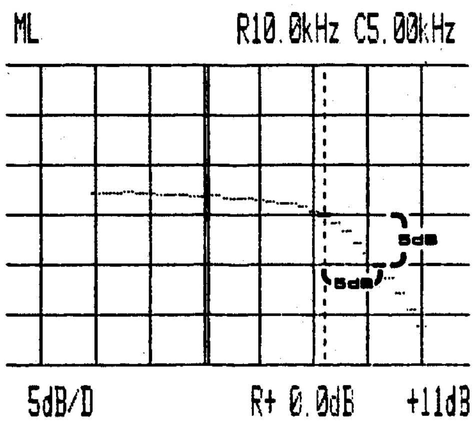


Figure #3. The cursor was moved to +11dB on the horizontal axis and the VERT REF - DISPLAY button pressed again. Here the compression is about 5dB when the input level changes by 5dB. Within this area of the input level, the saturation level can be found. Move the cursor to 10 KHz. Press MANUAL and BOTH buttons. Move the cursor to +15dB.

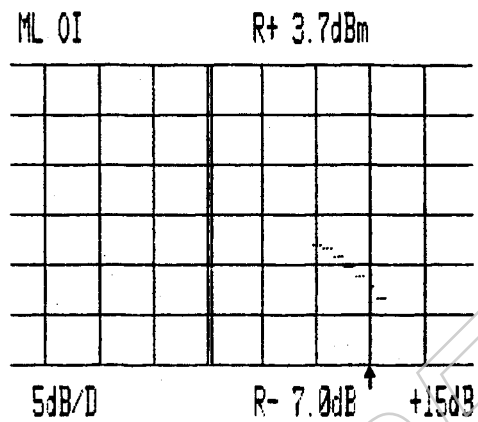


Figure #4. The input level is +3.7 dBm as indicated at the top of the display. Note that this level is not with respect to the reference level but is the same level that would be read in A.C. volts.

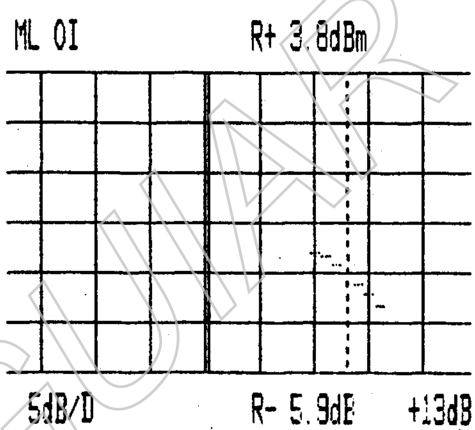


Figure #5. The cursor is moved to +13dB and the input level has gone up to +3.8 dBm.

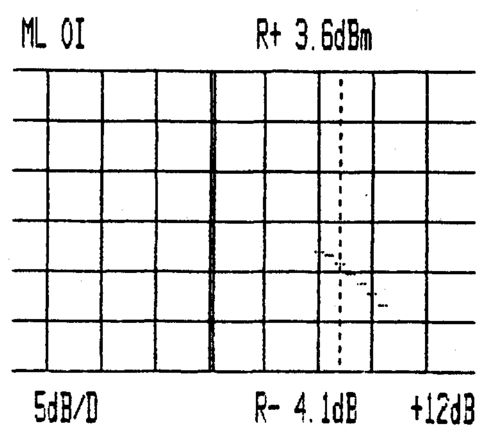


Figure #6. The cursor is moved to +12dB. The input level has gone down to +3.6 dBm. Therefore, the saturation level is +3.8 dBm or + 13 dB from the reference level.

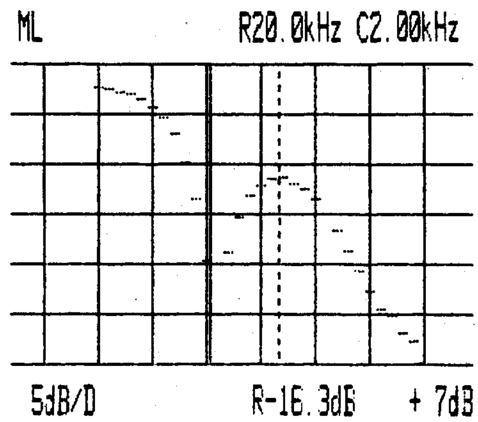


Figure #7. This curve shows the compression of a tape recorder that has been over driven. Note the $\frac{\sin x}{x}$ curve.

This shows that the "maximum level" can be at several different levels when the compression curve is run from the high to low level at "high frequencies".

ALL-IN-ONE INSTRUMENT FOR AUDIO AND TAPE MACHINE TESTING FOR THE AUDIO AND BROADCAST PROFESSIONAL

With the introduction of the 1510A Tape Recorder/Audio Test Instrument, the audio engineer has the capability of performing all of the necessary tests for maintenance, troubleshooting and general check-out of any professional audio device, whether it be tape recorder, film machine, mixing board, reference turntable, parametric equalizer, or any other outboard device. With the 1510A's exclusive asynchronous inputs and outputs, the instrument lends itself to system check-outs and remote location testing such as satellite, transmitter or studio testing; using either the 1510A's microprocessor-controlled generator or an external generator (the 1510A's inputs are totally auto-ranging and auto-tuning).

With its built-in CRT, the 1510A gives you unparalleled information: both alpha/numeric data on the screen plus graphic information for those applicable tests. Thus, we have combined the qualities of having an instrument with digital readout only, analog meter only, or an instrument having graphics plotting capability into one unit — the 1510A! This is all possible because of the built-in Z-80 microprocessor and display processor circuitry.

The 1510A has been engineered with the audio professional in mind. The two-channel outputs are electronically balanced and floating, the inputs are differential, and the output levels are from +30 dBm to -70 dBm into 600 Ω, with a pushbutton resolution of 0.1 dB. For those facilities with automation in mind, the IEEE-488 general purpose computer interface bus is available.

EXTENSIVE PROGRAMS STORED IN THE 1510's MEMORY EXECUTE FOURTEEN TESTS

2-CHANNEL AUTORANGING AC VOLTMETER

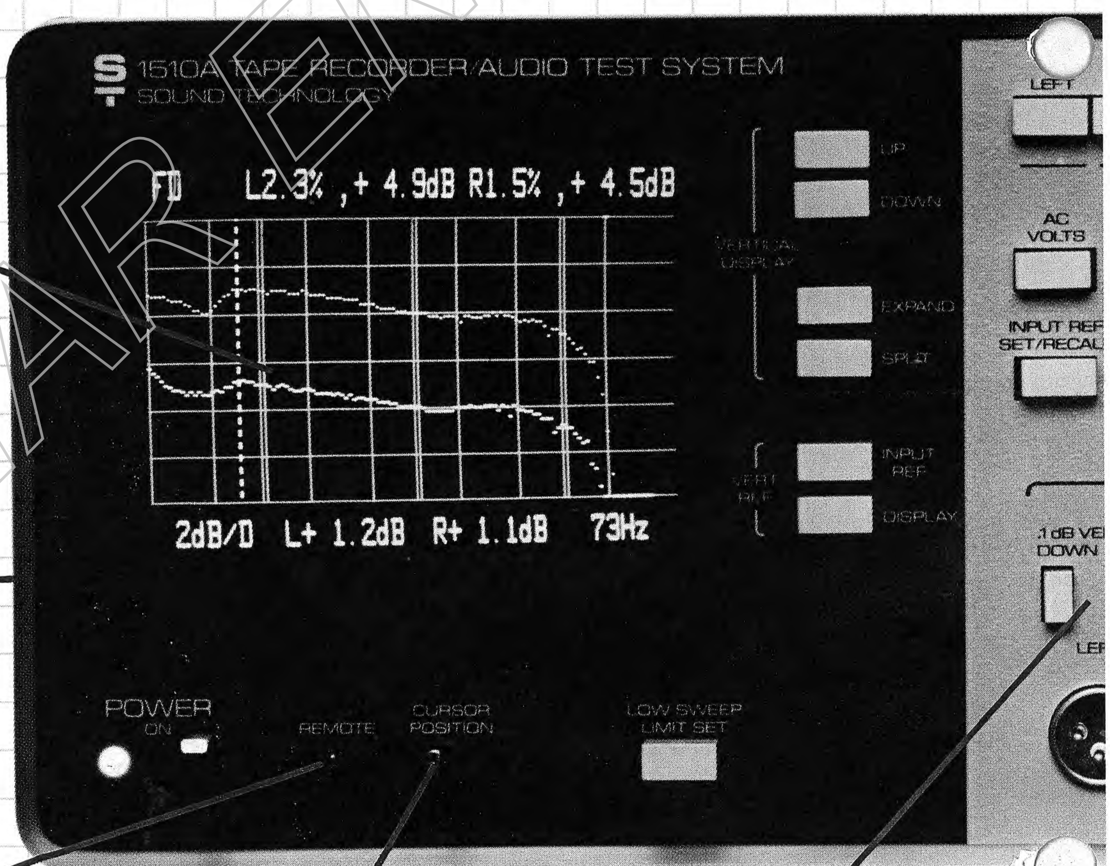
In the **AC Volts** function, the 1510A acts as a 2-channel auto-ranging AC voltmeter with both digital and analog displays. It can measure on the left channel only, right channel only, or both in rapid sequence. When **AC Volts** is selected, a 1 kHz test signal is output on both channels to be used for setting a reference. On the CRT display, vertical bars represent meter movements with full scale range shown at the top. The bottom line is used for the digital readout for both channels in volts and dBm/600 Ω.

MEASURE PHASE DIFFERENCE BETWEEN THE LEFT AND RIGHT CHANNELS

In the **Azimuth** test, the 1510A measures the phase difference between signals appearing at its left and right inputs, with the phase of the left input measured relative to the right input. It does this at four frequencies (2.8, 5.7, 11.8, and 15.8 kHz) and plots the results as vertical bars spaced along the horizontal frequency scale. Upon pressing the **Stop** button, the data may be read digitally by positioning the **Cursor**. In this test the 1510A also outputs these four frequencies in rapid sequence on both channels. The complete sequence is repeated 10 times per second in order to provide fast visual feed-back for making adjustments that affect relative phase.

MEASURE 2nd OR 3rd ORDER DISTORTION vs LEVEL

In the **Distortion** mode, the 1510A sweeps level in 1/2 dB steps from +20 to -10 dB around the reference voltage and plots distortion at each dB point. Using the **Cursor** in the after-test state, you can digitally read each analog data point on the curve, with the screen giving you both *% distortion* on the top, and distortion in *dB below the fundamental* on the bottom. The swept distortion test can be run on the left channel, right channel, or both channels for checking symmetry. Also, as with all of the 1510A swept tests, the operator can go into the **Manual** mode (or the Engineering mode, as it is sometimes called) and manually control the level of the generator, with 1/10th dB resolution, and get a real-time reading of the distortion at any level in percent and dB below the fundamental. Distortion measurements can be made at 315, 333, 400 and 1 kHz.



ALPHA-NUMERIC READOUT OF ALL TESTS ON INTEGRAL CRT

NTSC VIDEO & DEMOD. FLUTTER SIGNAL OUTPUTS FOR EXT. MONITORING (Rear Panel)

REMOTE L.E.D. TELLS YOU WHEN THE 1510A IS UNDER GPIB COMPUTER CONTROL

CURSOR GIVES YOU DIGITAL READOUT OF ANY POINT ON THE DISPLAY

+30 dBm TO -70 dBm (into 600 Ω) PUSHBUTTON SELECTABLE OUTPUTS WITH .1 dB RESOLUTION

MEASURE FREQUENCY RESPONSE

In the **Frequency Response** test, the 1510A microprocessor controls the programmable oscillator and generates a frequency sweep from 40 kHz to 20 Hz, comprised of 256 stepped discrete frequencies spaced into 123 frequency *windows* in the 1510A inputs. The results are plotted on the CRT as frequency vs level on a semi-logarithmic 2, 5, 1 audio style grid.

After the test, position the **Cursor** to record the level at any frequency. In the **Manual** mode, you control the generator frequency with the **Cursor** and look at any frequency and level real-time. You can sweep frequency on the left, right, or both channels. Sweeps can be automatically run at -20, -10, 0 or +10 dB.

SPOT FREQUENCY RESPONSE

The **Spot Frequency** test is a segmented frequency response test which minimizes test time. This test checks frequency response at each division on the screen and at 15 and 40 kHz (see Figure 1).

MEASURE FREQUENCY RESPONSE AND DISTORTION IN THE SAME TEST

Called up by pressing **3rd Distortion and Freq. Response** at the same time, this test is particularly handy for adjusting bias on machines utilizing magnetic particle mediums (tape recorders, film machines, etc.). In this test, frequency is first swept from 40 kHz down to any Low-Sweep-Limit (5 kHz for instance) after which a third order distortion reading will be taken at 0 dB. In this test, bias optimization can be obtained by viewing the compromise between frequency response and 3rd order distortion.

MEASURE CHANNEL SEPARATION vs FREQUENCY

In the **Channel Separation** test, the 1510A outputs a 1/3 octave frequency sweep from 20 kHz to 20 Hz on one channel, measures the signal as it appears at the 1510A input and compares that level to the signal level on the opposite channel. The ratio is plotted in dB at the position on the horizontal scale corresponding to the frequency measured. The **Manual Sweep Mode** can be used to review any one particular frequency's channel separation real-time. Using option 007, the 1/3rd octave spectrum analyzer, the noise floor can be reduced at each frequency measured in the Channel Separation test.

MEASURE COMPOSITE AND RESIDUAL NOISE

In the **Noise** test, noise is measured and compared to the pre-set, input-reference level, which was established in the **AC Volts** test. The ratio in dB is shown at the top of the screen. A vertical bar represents the instantaneous value of the noise and has a meter-like movement with dynamics determined by the standard you select.

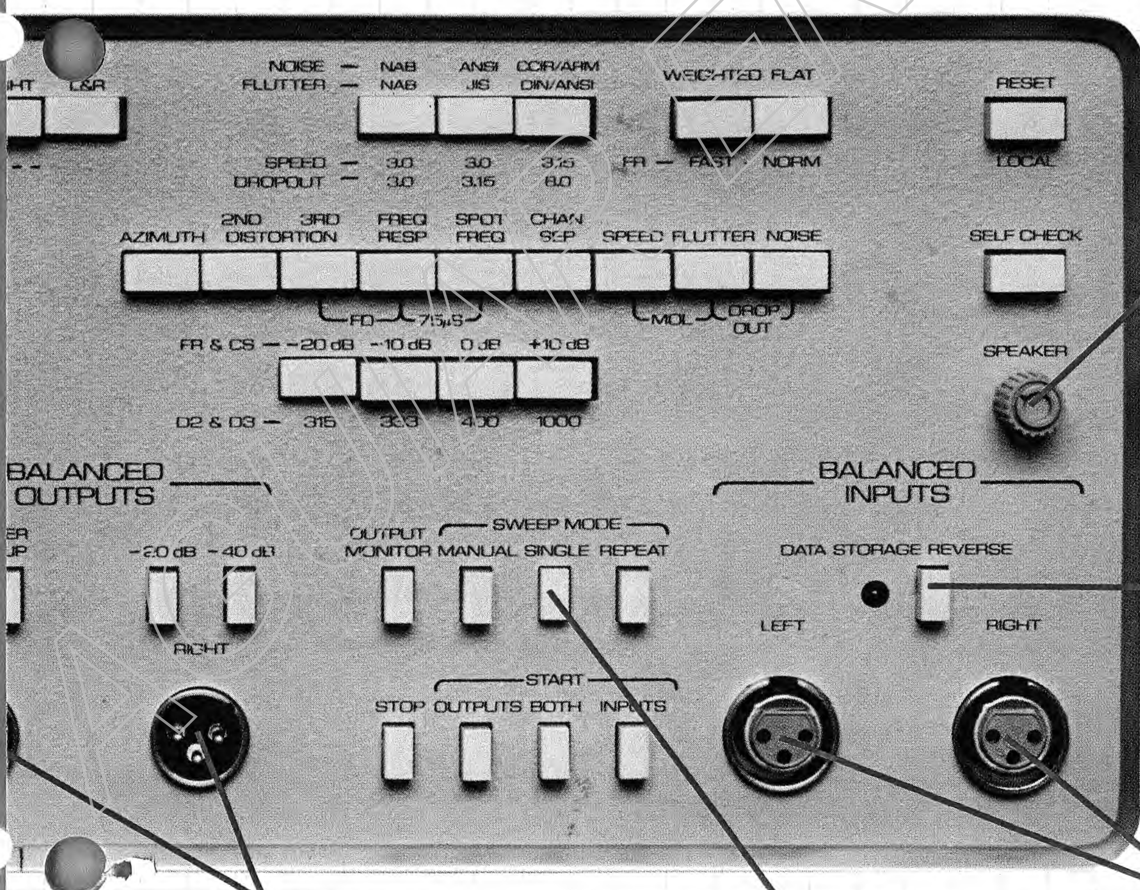
With the spectrum analyzer option installed, the 1510A automatically does a two-channel spectral sweep (one-third octave resolution) of the noise components from 20 kHz to 20 Hz. In the **Manual** mode, using the **Cursor**, you can select any one filter for real-time noise analysis or tuned voltmeter applications.

MEASURE WOW AND FLUTTER WITH SPECTRAL ANALYSIS

In the **Flutter** mode, the 1510A acts as an auto-ranging wow and flutter meter with a vertical bar simulating a meter movement with dynamics according to the user-selected standard. On the top line of the screen the 2-sigma, smoothed value of the wow and flutter is also printed (see Figure 2). With the one-third octave spectrum analyzer option, spectral analysis of wow and flutter is automatically plotted from 200 Hz to 0.5 Hz. Then, using the once-around frequency formula, the diameter of any offending part can be derived using the data taken from the 1510A screen.

MEASURE Δ SPEED AND DRIFT

Using a standard 3.00 kHz or 3.15 kHz test tape, the 1510A will plot 10 sec. averages of speed error vs time from 10 to 600 seconds. The 1510A screen also gives the user Instantaneous Speed Error for *ballpark* measurements to be used in conjunction with the



MONITOR TEST TAPES AND FLUTTER COMPONENTS WITH BUILT-IN SPEAKER

ALLOWS THE USER TO MAKE COMPARATIVE MEASUREMENTS USING ONE 1510A CHANNEL

TWO CHANNEL FULLY BALANCED AND FLOATING OUTPUTS WITH RECESSED XLR CONNECTORS

LET THE 1510A AUTOMATICALLY SWEEP EACH TEST, OR **YOU** CONTROL IN THE MANUAL MODE USING THE CURSOR

FULLY AUTORANGING DIFFERENTIAL INPUTS MEASURE VOLTAGES FROM 200 μV to 40 V more accurate 10 second averages. After the test, the **Cursor** is used to display the Absolute Speed Error at any point on the time axis. Using the **Display REF** button, the display changes from **Speed Error** to **Drift.**

MEASURE DROPOUT vs TIME

In the **Dropout** test, the 1510A measures and plots dropouts vs time from 20 sec. to 1000 sec., in 20-second intervals. Also, at the completion of the test, the 1510A screen gives you the results of the four IEC Dropout Annoyance categories per IEC #94, Sept. 1981, which are based on occurrence, depth, duration, and when they occur with respect to each other (clustering). The 1510A will detect dropouts using the three standard frequencies: 3.00 kHz, 3.15 kHz and 8.00 kHz (see Figure 3).

MEASURE MOL — MAXIMUM OPERATING LEVEL

With the **MOL** option installed, the 1510A plots output vs input at any one of the 31 **Cursor** selected frequencies from 40 Hz to 40 kHz. This test is beneficial when you need to check tape or film saturation, trigger points for compressor/limiters, or noise reduction systems. Using the **Data Storage Reversed** button, a comparison of any two systems can be made, using the same 1510A input channel (see Figure 4).

THE 1510A IS MODULAR

All of the 1510A options are field retrofittable. With the 1510A motherboard/daughterboard arrangement, you simply remove the dust cover and plug in the option board . . . within five minutes you are in business! The following options are available for the 1510A:

OPTION 007, ONE-THIRD OCTAVE SPECTRAL ANALYSIS OF NOISE AND FLUTTER

ANSI Class II filters cover 20 kHz to 20 Hz, one-third octave resolution for noise and 200 Hz to 0.5 Hz for wow and flutter. The filters are also used in the Channel Separation test to lower the noise floor.

OPTION 009, GPIB COMPUTER INTERFACE BUS

For automated 1510A tests, the IEEE-488 bus is available for interfacing to any computer having the IEEE-488 interface. Sound Technology has sample programs available, written in **Basic** for the HP-85 computer. An example of the usefulness of the bus is our program which does seven comprehensive tests in 28 seconds. We also have a program available to automate the playback response of a two-head tape recorder.

OPTION 010, CCIR 468-2 NOISE WEIGHTING STANDARD

For those customers who prefer the European version of the CCIR standard, rather than the popular CCIR/ARM, which is standard on the 1510A.

OPTION 011, MOL — MAXIMUM OPERATING LEVEL TEST

An Input vs Output test which can be run at any one of 31 frequencies in the range from 40 kHz to 40 Hz.

OPTION 012, IEC DROPOUT TEST

Measures and plots dropout vs time as per IEC #94, Sept. 1981.

PERIPHERAL ITEMS AVAILABLE FOR USE WITH THE 1510A:

VP-150 VIDEO PRINTER

Distributed by Sound Technology, this printer interfaces with the **Video Out** on the back of the 1510A and gives the user hard copy of any 1510A display.

TR-150 TECHNICAL TEST RECORD

The **TR-150 Test Record** gives the 1510A user the capability of analyzing his reference turntable with the same precision as is afforded by the 1510A with other audio devices. The test record gives the user exclusive and comprehensive test bands on a high-quality, half-speed mastered, virgin vinyl pressing. Each side of the record is identical, so that many hundreds of passes are allowed on this record before it is worn.

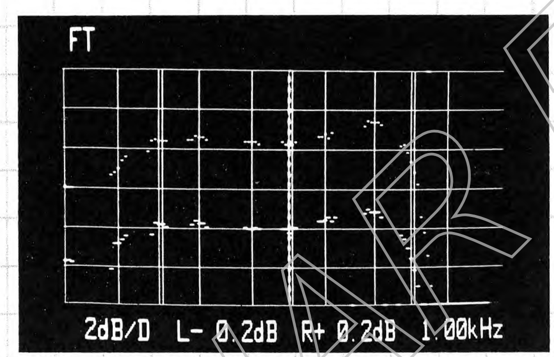


Figure 1. SPOT FREQUENCY RESPONSE
A fast, segmented frequency response sweep from 40 kHz to 20 Hz. Cursor shows frequency and level at each data point.

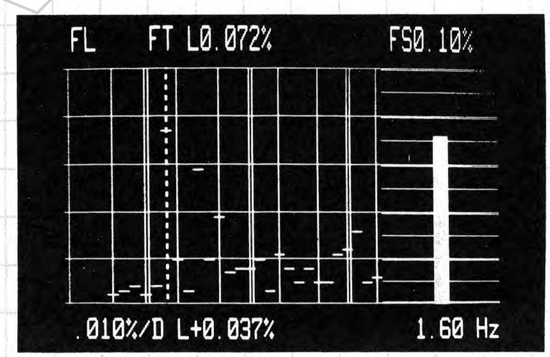


Figure 2. FLUTTER
Dynamic bar graph shows instantaneous flutter. Upper digital readout gives 2-sigma smoothed average, and graph shows spectral analysis of wow and flutter from 200 Hz to 0.5 Hz.

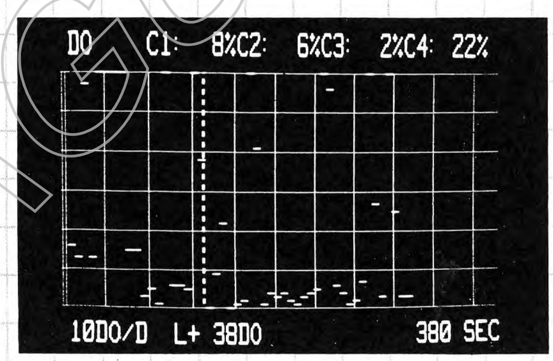


Figure 3. DROPOUT TEST
Measure and plot Dropouts vs Time from 20 to 1000 sec. Dropouts also measured and displayed per four IEC Dropout categories.

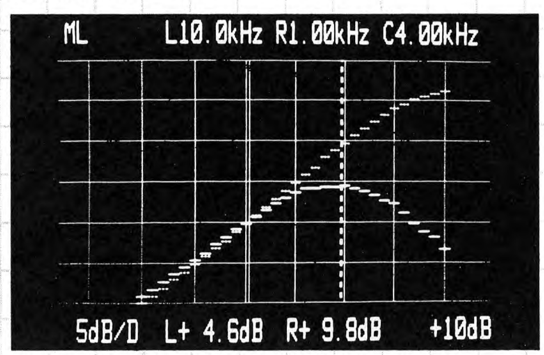
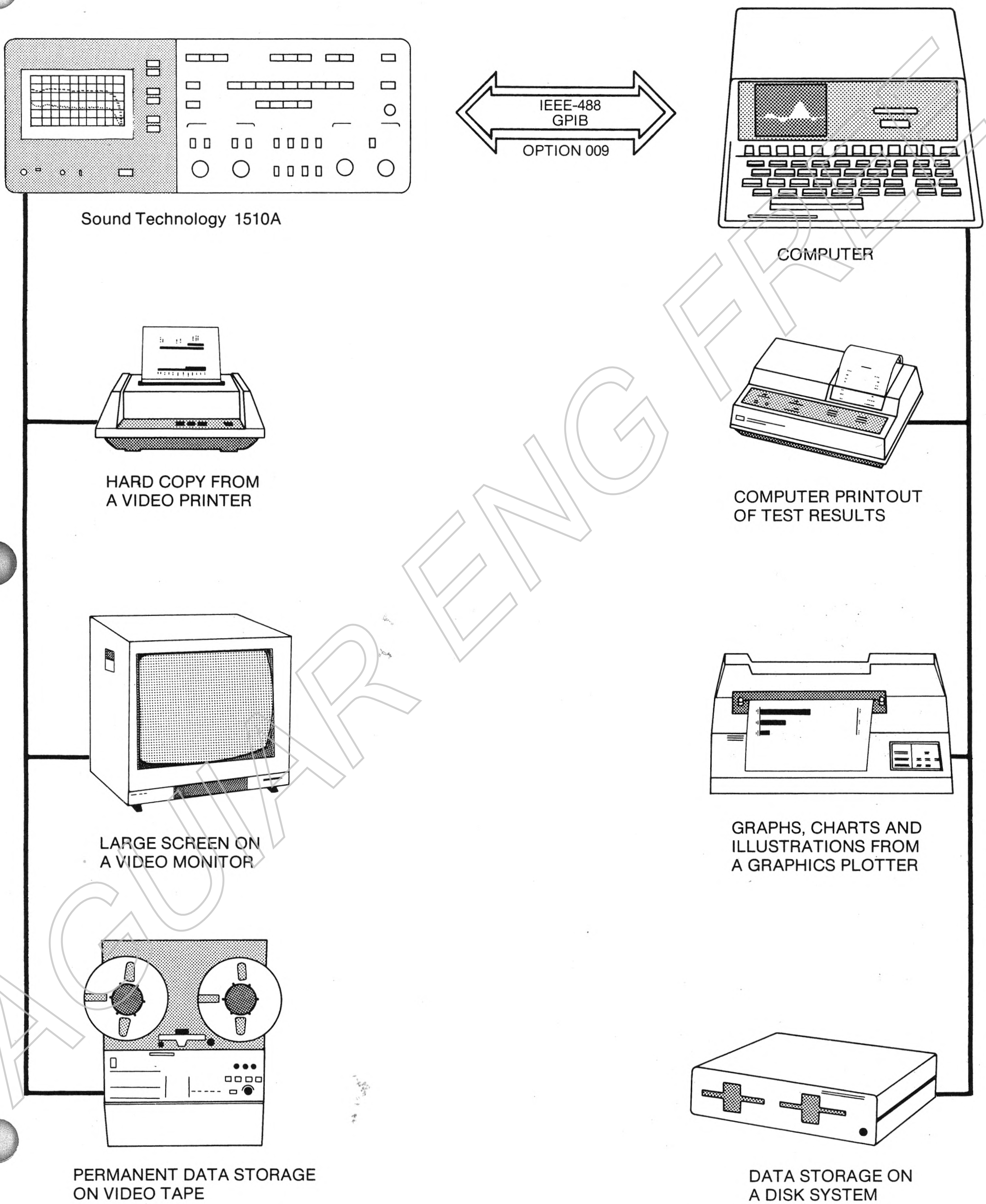


Figure 4. MOL - MAXIMUM OPERATING LEVEL
Sweeping input vs output test done at any one of 31 different frequencies. Check tape saturation, noise reduction systems or compressor/limiter trigger points.

SYSTEM FLEXIBILITY . . . with the 1510A you can generate hard copies of test results on the video printer, store test sequences on a videotape recorder, or display tests on any video monitor. Add option 009 and have a computer run all of your tests, including a 20 kHz bandwidth Thd test. The computer can evaluate the data and print results. For maintenance records, use the computer's printer for alpha/ numeric printout, or a graphics plotter for multicolor 8-1/2" by 11" graphs of test data. Store test results on a floppy disk for permanent storage, or for later retrieval as a data base.



SPECIFICATIONS

OUTPUT

Balanced and Floating Dual Channel

Impedance: 50 Ω ± 1%.
Response: 20 Hz to 40 kHz < ± 0.1 dB.
Maximum Levels: +30 dBm for distortion and MOL test. +20 dBm for frequency response and channel separation test. +10 dBm for AC volts, Δ Speed, Flutter and Dropout tests.
Level Control: 0.1 dB vernier with a 20 dB range.
Level Attenuation: Selectable 20, 40 or 60 dB.
Differential Residual Noise: < 50 μV.

INPUT

Differential Dual Channel

Impedance: 100 K Ω ± 1%.
Maximum Level: +34 dBm (42V rms).
Minimum Level: -70 dBm (245 μV rms).
Common Mode Rejection: > 60 dB at 60 Hz.
Response: 20 Hz to 40 kHz < ± 0.1 dB.
3 dB Bandwidth: > 100 kHz.

AC VOLTS

Measure Left Channel Only, Right Channel Only, or Both Channels

Accuracy: True rms, ± 2% or reading with a crest factor no greater than 6.
Autoranging: 300 μV to 40 V rms full scale. 10 dB steps.
Residual Noise: < 100 μV.
Display: Vertical bar graph.
Digital readout of ACV: 3 digits; dBM: 0.1 dB.

AZIMUTH/PHASE METER

Measurement Frequencies: 2.8 ± 1, 5.7 ± 1, 11.8 $^{+1}/_{-4}$, 15.8 ± 1 kHz.
Cycle Time: 0.1 seconds through noted frequencies.
Measurement Range: ± 180° of electrical phase.
Accuracy: ± 2° electrical phase (Eqv. to 1/26 minute of arc in cassette format).
Display: Dynamic; shows instantaneous phase error between L and R channels, plus digital readout of error at measured frequencies.

DISTORTION

Measure & Display: 2nd or 3rd Harmonic vs Level.
Fundamental Frequencies: User selectable 315, 333, 400 or 1000 Hz.
Accuracy: ± 5% of reading.
Residual Distortion: Output < .01%; Input < .025%.
Input Level from Recorder: Display shows distortion vs level in 1 dB steps.
Output Level to Recorder: +20 to -10 dB in 1/2 dB steps referred to preset output.
Sweep time: < 40 secs, +20 to -10 dB. Can be terminated earlier with STOP button or at Low Sweep Limit or controlled manually.
Display: Trace shows plot of distortion vs input level.
Digital readout of distortion in % and dB.

FREQUENCY RESPONSE

Frequency Range: Continuous sweep from 40 kHz to 20 Hz. Can be terminated earlier with STOP button or Low Sweep Limit or controlled manually.
Accuracy/Resolution: ± 5% of reading/± 3%.
Amplitude Accuracy/Flatness: ± 0.1 dB / 0.1 dB
Minimum Input S/N Ratio: 20 dB.
Max Input Signal Slope: 60 dB per octave in normal mode.
Sweep Time: 34 secs. from 40 kHz to 20 Hz.
Output Level Offsets: User selectable +10, 0, -10 or -20 ± 0.1 dB.
Display: Trace shows level at 123 discrete frequencies. Digital frequency readout. Level readout referenced to input or display.

SPOT FREQUENCY RESPONSE

Frequency Spots: 20, 50, 100, 200, 500, 1K, 2K, 5K, from 10K to 20K and 40 kHz.
Sweep Time: 12 secs. in fast mode; 17 secs. in normal mode.
Other Specifications: Same as Frequency Response.

CHANNEL SEPARATION

Frequency Range: Continuous sweep from 20 kHz to 20 Hz with 1/3 octave resolution.
Residual Noise: < 100 μV.
Amplitude Accuracy: ± 1 dB.
Output Level Offsets: User selectable +10, 0, -10 or -20 dB ± 0.1 dB.

Δ SPEED/DRIFT

Measurement Time/Range: 0 to 610 secs./± 4%.
Output Frequency: 3.0 kHz (NAB, JIS) or 3.15 kHz (DIN, ANSI) ± .005%.
Display: Trace shows 10 second average speed error vs time. Digital readouts of both instantaneous and 10 sec. avg. error.

FLUTTER

Output Frequency: Same as speed and drift.
Autoranging: .03 to 10% full scale.
Accuracy/Residual Flutter: ± 5% of reading/< ± .005%.
Detection, Weighting and Display Dynamics: Per NAB, JIS, or DIN/ANSI standards.
Display: Vertical bar graph. Digital readout shows 2-Sigma signal (smoothed, 95% of peak).

NOISE

Residual Noise: (1V reference) Flat -92 dB, Weighted -97 dB.
Flat Response: -3 dB points at 20 Hz and 20 kHz.
Detection, Weighting and Display Dynamics: Per NAB, ANSI, CCIR/ARM OR CCIR standards.
Output: Floating 50 Ω termination.
Accuracy: ± 5%.
Display: Autoranged vertical bar graph with digital readout referred to input ref. level.

GENERAL

Rear Panel Outputs: Composite video signal, 1V p-p ± 6 dB, 75 Ω, negative sync. Demodulated flutter signal, autoranged, < 15V p-p, 1K Ω.
Power: 100, 120, 220, 240 V, 48-66 Hz, 120 W.
Dimensions - HWD: 7.0 X 17.0 X 16.4" (18 X 43 X 42 cm).
Weight - Net/Ship: 34 lbs. (15.5 kg) / 43 lbs. (19.5 kg).
Environmental: 90% RH, +50 to +104° F (+10 to +40°C).

OPTIONS

1/3 OCTAVE SPECTRUM ANALYZER

Accuracy: 1.0 dB.
Rejection Ratio: > 60 dB.
Maximum Peak to Peak Pass Band Ripple: < 1 dB.
Center Frequency Accuracy: < 3%.
Typical Filter Slope: > 50 dB per octave.
Dynamic Range: > 90 dB.
Filter: ANSI S1.11-1966 (R1975) Third octave, class II, type 0.
Noise Frequency Range: 20 Hz to 20 kHz.
Flutter Frequency Range: 0.5 Hz to 200 Hz.

IEEE-488 GENERAL PURPOSE INTERFACE BUS

Compatible with the IEEE-488, ANSI MC1.1 and IEC 625-1 bus configurations. All front panel buttons and functions are accessible from GPIB.

CCIR 468-2 FILTER

Replaces CCIR/ARM filter.

MOL/MAXIMUM OPERATING LEVEL

Measurement & Display: Output level vs Input level at test frequency.
Measurement Frequencies: 31 user selectable frequencies between 40 Hz to 40 kHz.
Accuracy: 5%.
Output Level: -10 to +20 dB.
Sweep Time: 33 sec.

DROPOUT

Output Frequencies: 3.0, 3.15 and 8.0 kHz.
Measurement Time/Range: 1000 secs. in 20 sec. steps/0 to 253 dropouts per step.
Standard: IEC #94, Sept. 1981.

Printed in U.S.A.
1510A 5M 1182

STL

STANDARD TAPE LABORATORY, INC.

26120 EDEN LANDING ROAD, HAYWARD, CALIFORNIA 94545

funke & associates
908 Marilyn Drive
Campbell, CA 95008
408/866-0648

January 1, 1985

TEST TAPES FOR SOUND TECHNOLOGY TAPE RECORDER TEST SYSTEM

Standard Tape Laboratory is represented by **funke & associates** in the USA for sales of the special test tapes and special magnetic test films. Orders placed within the USA should be placed directly with Standard Tape Laboratory, or with **funke & associates** .

Orders for shipment outside of the USA should be placed with your Sound Technology dealer, your Standard Tape Laboratory dealer, or directly with Standard Tape Laboratory.

AVAILABLE TEST TAPES

The Multi-purpose test tape for use with the analyzer contains the 4 tone azimuth test signal, special frequency sweep runs, and two or three level set tones. 1" & 2" test tapes contain twice the number of sweep runs as the ¼" and cassette tapes. Additionally, a Flutter/Speed test tape is available for testing these functions (3150 Hz.).

Please use the table on the reverse side to determine the part number and price of the tapes that you require. Listed Part #'s of reel to reel tapes are for full track. Tapes marked ** are also available in 2 channel ½ track (add -2 to Part #) and 2 channel ¼ track (add -4 to Part #). Price is the same for full track.
Note: 2 channel ½ track IEC tapes are to USA track dimensions!

All Multi-purpose, reel to reel test tapes are recorded to the standards listed below:

3 3/4 IPS	NAB and IEC
7 1/2 IPS	NAB
15 IPS	NAB
30 IPS	AES and IEC, current recommendation.

7 1/2 & 15 IPS tapes are also available to IEC standard: Add -IEC to Part #.
Level Sets are 185 and (320) nWb/m, ANSI(DIN): Prices are the same as NAB.

Cassette test tapes are recorded to the new 1981 IEC standard (3180–120 μsec, compensated).
Broadcast carts are recorded to the 1976 NAB standard.

IMPORTANT Specify the cartridge type from this list by adding the appropriate letter code to the Part #:

-AR (Aristocart), -AS (Aristocart AA), -AP (A2 Audiopak), -AA (AA3 Audiopak), -FI (Fidelipac 350), -MA (Mastercart), -MC (Mastercart II), -SC (Scotchcart).

Note: ANSI (DIN) - U.S. vs. European (DIN and IEC) methods of measurement result in level discrepancies listed.

FUNKE AND ASSOCIATES
908 MARILYN DRIVE
CAMPBELL, CALIFORNIA 95008
Telephone: (408) 866-0648

ORDERING TABLE

Tape System Characteristics			Multi-purpose Test Tape Level, Azimuth, Frequency Response					Flutter/Speed Test Tape	
Tape Width	Speed IPS	Format	Level Tones - nWb/m ANSI(DIN) 1	2	3	Part #	Price US $*	Part #	Price US $*
150 mil	1 7/8	Cassette	(160)	(200) Dolby		TT-86	100	TT-29	45
¼"	3 3/4	Reel	185	(250)		TT-01**	95	TT-51-1	50
¼"	7 1/2	Reel	185	260		TT-02**	90	TT-52-1	56
¼"	7 1/2	Broad Cart (mono)	160	250		TT-34-1	100	TT-35	63
¼"	7 1/2	Broad Cart (stereo)	160	250		TT-34-2	100	TT-35	63
¼"	15	Reel	185	260		TT-03**	95	TT-53-1	63
¼"	30	Reel	185	260	(320)	TT-04**	100	TT-54-1	69
½"	3 3/4	Reel	185	(250)		TT-23	200	TT-60-1	63
½"	7 1/2	Reel	185	260		TT-05	190	TT-61-1	69
½"	15	Reel	185	260		TT-06	200	TT-62-1	75
½"	30	Reel	185	260	(320)	TT-07	210	TT-63-1	81
1"	3 3/4	Reel	185	(250)		TT-24	335	TT-70-1	119
1"	7 1/2	Reel	185	260		TT-08	290	TT-71-1	125
1"	15	Reel	185	260		TT-09	300	TT-72-1	144
1"	30	Reel	185	260	(320)	TT-12	340	TT-73-1	156
2"	7 1/2	Reel	185	260		TT-19	580	N.A.	
2"	15	Reel	185	260		TT-20	550	N.A.	
2"	30	Reel	185	260	(320)	TT-21	630	N.A.	
2" Quadruplex Video Recorders - Audio Test Only						TT-16	440	N.A.	
1" Type "C" Video Recorders - Audio Test Only						TT-17	350	N.A.	
35MM Magnetic 5 Mil Full coat (SMPTE & IEC)			185			TT-90	430	TZ-90	260
16MM Magnetic 5 Mil Full coat (SMPTE & IEC)			185			TT-10	200	TZ-10	120

*Prices subject to change without notice
**Also available in 2 channel, ½ track and 2 channel, ¼ track; add -2 or -4 to Part#; price same as full track.

SOUND TECHNOLOGY

Leaders in test and measurement for over a decade.

U.S. PRICE LIST

EFFECTIVE AUGUST 1, 1985

1000 SERIES ACCESSORIES

STOCK NUMBER	DESCRIPTION	PRICE
Model 100	Matching Transformer (50 to 300 Ω)	$ 95.00
Model 105	Matching Transformer (50 to 75 Ω)	95.00
*110	Frequency Converter with 10.7 MHz Marker	125.00
*120	FM Dial Calibration Standard	110.00
31000A	Accessory Kit (1 Model 100, 4 BNC/BNC cables, 2 BNC/Banana adapters and 1 BNC/Phono adapter)	125.00
3110-0004	300 Ω connector for Model 100	3.00
00100-30001	300 Ω connector with cable for Model 100	6.00
8000-0018	dBf Dial for 1000A	11.00

*for 1000A only

1500 SERIES ACCESSORIES

STOCK NUMBER	DESCRIPTION	PRICE
7100-0013	Dual Coax Cable, 60" long, BNC/BNC connectors	$ 10.00
7100-0017	Balanced XLR Cable (Male to Female) 120" Black	40.00
7100-0018	Balanced XLR Cable (Male to Female) 120" Red	40.00
31038A	XLR male-to-BNC Jack Adapter	15.00
31039A	XLR female-to-BNC Jack Adapter	15.00
31040A	4 XLR to XLR cables, 2 red & 2 black for 1510A	145.00
31015A	1500A Accessory Kit (2 dual coax cables and 4 RCA/BNC Adapters)	65.00

1700 SERIES ACCESSORIES

STOCK NUMBER	DESCRIPTION	PRICE
1200-6000	8 Ω, 1% tolerance, 250 watt, non-inductive load resistor	$ 40.00
31001	Factory retrofit of Auto Set Level (option 003) into 1700A/B, 1701A and 1710A	450.00
*31003	Factory retrofit of IM Analyzer (option 004) into 1700A/B and 1701A only	1295.00

*not possible for 1710A

HARDWARE

STOCK NUMBER	DESCRIPTION	PRICE
Option 008	Flight Case for all units except 1000A and 170	$ 240.00
7100-0000	Replacement Power Cord for all units	4.75
3100-0005	BNC/Dual Banana adapter	8.00
3100-0006	BNC/Phono Jack (RCA) adapter	10.50
7100-0001	Single coax cable, 60" long, BNC/BNC connectors	18.00

TERMS: Net 30 days on approval of credit. All prices FOB Campbell, California. Prices subject to change without notice. $5.00 service charge on all parts orders.

WARRANTY: Two years parts and labor on 1700 series distortion analyzers sold in USA. One year parts and labor on all other instruments manufactured by Sound Technology and sold in USA.

SOUND TECHNOLOGY
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