

# Instruction Manual

**Tektronix**

AA 5001

Programmable Distortion Analyzer with Option 02  
070-4598-01

**Warning**  
The servicing instructions are for use by qualified personnel only. To avoid personal injury, do not perform any servicing unless you are qualified to do so. Refer to the Safety Summary prior to performing service.

Please check for change information at the rear of this manual.

First Printing: October 1982  
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# OPERATORS SAFETY SUMMARY

This general safety information is for both operating and servicing personnel. Specific warnings and cautions will be found throughout the manual where they apply, but may not appear in this summary.

AA 5001

## TERMS

In This Manual

CAUTION statements identify conditions or practices that can result in damage to the equipment or other property.

WARNING statements identify conditions or practices that can result in personal injury or loss of life.

## As Marked on Equipment

CAUTION indicates a personal injury hazard not immediately accessible as one reads the marking, or a hazard to property including the equipment itself.

DANGER indicates a personal injury hazard immediately accessible as one reads the marking.

## SYMBOLS

In This Manual



This symbol indicates where applicable cautionary or other information is to be found.



Protective ground (earth) terminal.



ATTENTION—refer to manual.



Refer to manual.

**Grounding the Product**  
This product is grounded through the grounding conductor of the power module power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting to the product input or output terminals. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

## Danger Arising From Loss of Ground

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulating) can render an electric shock.

## Use the Proper Power Cord

Use only the power cord and connector specified for your product.

Use only a power cord that is in good condition.

Refer cord and connector changes to qualified service personnel.

## Use the Proper Fuse

To avoid fire hazard, use only the fuses specified in the parts list for your product, and which is identical in type, voltage rating and current rating.

Refer fuse replacement to qualified service personnel.

## Do Not Operate in Explosive Atmospheres

To avoid explosion, do not operate this product in an atmosphere of explosive gases unless it has been specifically certified for such operation.

## Do Not Operate Plug-in Unit Without Covers

To avoid personal injury, do not operate this product with out covers or panels installed. Do not apply power to the plug-in via a plug-in extender.

This product is designed to operate from a power module that does not apply more than 250 volts rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

## Power Source



# SERVICING SAFETY SUMMARY

## FOR QUALIFIED SERVICE PERSONNEL ONLY

Refer also to the preceding Operators Safety Summary

### Do Not Service Alone

Do not perform internal service or adjustment of this product unless another person capable of rendering first aid and resuscitation is present.

### Use Care When Servicing With Power On

Dangerous voltages may exist at several points in this product. To avoid personal injury, do not touch exposed connections and components while power is on.

Disconnect power before removing protective panels, soldering, or replacing components.

### Power Source

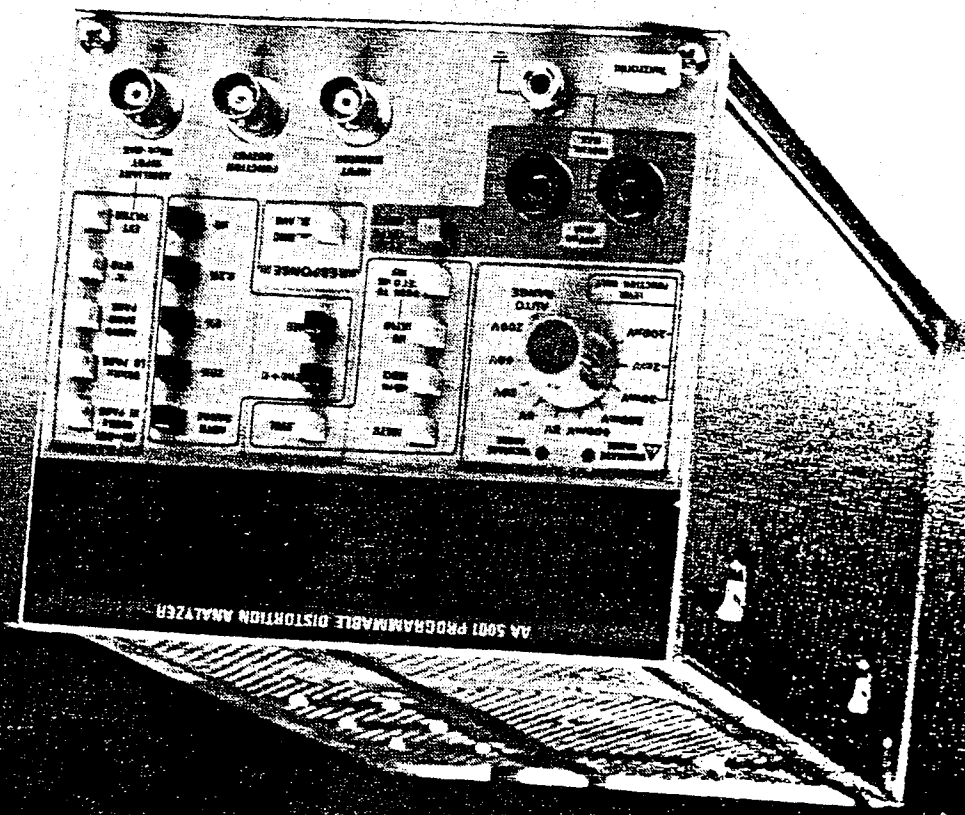
This product is intended to operate from a power module that will not apply more than 250 volts rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

### Do Not Wear Jewelry

Remove jewelry prior to servicing. Rings, necklaces, and other metallic objects could come into contact with dangerous voltages and currents.



AA 5001 Programmable Distortion Analyzer.



4598 C1

AA 5001





# SPECIFICATION

the rear interface. This allows flexibility in interconnection with other instruments such as filters, chart recorders, spectrum analyzers, oscilloscopes, etc.

## Performance Conditions

The electrical characteristics in this specification are valid only if the AA 5001 has been adjusted at an ambient temperature between  $+20^{\circ}\text{C}$  and  $+30^{\circ}\text{C}$ . The instrument must be in a noncondensing environment whose limits are described under the environmental part. Allow twenty minutes warm-up time for operation to specified accuracy: sixty minutes after exposure to or storage in a high humidity (condensing) environment. Any conditions that are unique to a particular characteristic are expressly stated as part of that characteristic. Unless specifically noted, all performance specifications are valid using only rms response only.

The electrical and environmental performance limits, together with their related validation procedures, comprise a complete statement of the electrical and environmental performance of a calibrated instrument.

Items listed in the Performance Requirements column of the Electrical Characteristics are verified by completing the Performance Check in the Calibration section of this manual. Items listed in the Supplemental Information column are not verified in this manual.

## Instrument Description

The AA 5001 is a fully automatic programmable distortion analyzer, packaged as a two-wide TM 5000 plug-in. Total harmonic distortion, SMPTE/DIN intermodulation distortion and CCIF two-tone difference frequency distortion are measured. Distortion set level, frequency tuning and nulling are fully automatic, requiring no operator adjustment. Distortion readout is provided in percent or dB.

The AA 5001 is also a high sensitivity, autorange, audio frequency voltmeter. Readings may be in volts, dBm, or dB relative to any arbitrary reference.

Filters are included which allow bandwidth limiting or weighted measurement of noise. A hum rejection filter is also provided as are provisions for an external filter.

All readings are displayed on a 3-1/2 digit readout and can be remotely sent. An uncalibrated analog readout is also provided to aid in manual nulling and peaking applications. Ac to dc detection (response) is either true rms or average (quasi-peak in Option 02 instruments).

Ac input and output connections are available on both the front panel and the rear interface. Dc signals, corresponding to the displayed reading, are available through



Table 1-1  
ELECTRICAL CHARACTERISTICS

Characteristics	Performance Requirement	Supplemental Information
INPUT (all functions) Impedance	100 k $\Omega$ , $\pm$ 2%, each side to ground	Full differential. Each side ac coupled through 1 $\mu$ F and shunted to ground by approximately equal to 200 pF. Dual banan jack connectors at 0.750 inch spacing with ground connector additionally provided.
Input ranges	200 $\mu$ V to 200 V in 10 steps (2-6 sequence from 200 mV to 200 V)	Range selection is manual or automatic. Autorange time is typically < 1 second. Separate increase range and decrease range indicators illuminate whenever input level does not fall within optimum window for selected range. For specified instrument performance both indicators must be extinguished.
Maximum input voltage	300 V peak, 200 V rms either input to ground or differentially. Will recover without damage from continuous overloads of 120 V rms or 200 V rms for 30 minutes in all ranges. For linear response, peak input voltage must not exceed 3 times INPUT RANGE setting.	300 V peak, 200 V rms either input to ground or differentially. Will recover without damage from continuous overloads of 120 V rms or 200 V rms for 30 minutes in all ranges. For linear response, peak input voltage must not exceed 3 times INPUT RANGE setting.
Common mode rejection (inputs shorted)	$\geq$ 50 dB at 50 or 60 Hz for common mode signals up to one-half of selected input range or 50 mV, whichever is greater.	Typically $\geq$ 40 dB to 300 kHz.
LEVEL FUNCTION Modes	Volts dB modes	Volts, dBm (600 $\Omega$ ), or dB ratio with push to set 0 dB reference. Input range determines display range. Single effective range in dB modes with 0.1 dB resolution. Stored 0 dB reference is unaffected by subsequent changes in mode or function.
Accuracy (level ranging indicators extinguished)	Within +2% $\pm$ 1 count $\pm$ 0.3 dB $\pm$	
20 Hz to 20 kHz	Within +4% $\pm$ 2 counts $\pm$ 0.5 dB $\pm$	
1 Hz to 100 kHz Bandwidth (no filters selected)	At least 300 kHz	



Characteristics	Performance Requirement	Supplemental Information
Residual noise (Inputs shorted, T ≤ +40°C)	≤ 3.0 μV (-108 dBm) with 80 kHz, 400 Hz filters. ≤ 1.5 μV (-114 dBm) with A weighting filter. (Standard instrument only). ≤ 5.0 μV (-104 dBm) with CCIR weighting and quasi-peak response (Option 02 only).	Fully automatic notch filter tuning and nulling for valid test signals with 10% or less THD + N. Midband signal THD + N can degrade to 30% without loss of lock following initial tuning for SINAD testing. Typical or average measurement settling time is 2.5 seconds above 100 Hz increasing by approximately 1 sec/octave below 100 Hz.
TOTAL HARMONIC DISTORTION PLUS NOISE FUNCTION	10 Hz to 100 kHz	Operation
Fundamental frequency range	60 mV (-22 dBm)	Minimum input level
Accuracy	Within ± 10% (± 1 dB) for harmonics ≤ 100 kHz. Within ± 20% (± 2 dB) for harmonics ≤ 300 kHz.	Autorangeing % or dB modes only. 100% reference level is total input signal amplitude including distortion and noise components. Accuracy may also be limited by the effects of residual THD + N and filter selection.
20 Hz to 20 kHz 10 Hz to 100 kHz	Residual THD + N (V <sub>r</sub> ) ≥ 250 mV, T ≤ +40°C)	System specification with any SG5010 or SG 505 oscillator, all distortion, noise, and nulling error sources combined.
20 Hz to 20 kHz with 80 kHz noise limiting filter 10 Hz to 100 kHz, no filter	≤ 0.0032% (-90 dB) ≤ 0.010% (-80 dB)	At least 10 dB below specified residual THD + N or the actual signal THD, whichever is greater.
Typical fundamental rejection		

Table 1-1 (cont)



Table 1-1 (cont)

Characteristics	Performance Requirement	Supplemental Information
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INTERMODULATION DISTORTION FUNCTION Operation	SMPTe and DIN tests Frequency range (upper tone) IM frequency range (lower tone) Level ratio range Residual IMD ( $V_m$ ) $\geq 250$ mV, $T \leq +40^\circ\text{C}$ .	Fully automatic SMPTe/DIN or CCIF difference tone test selection depending upon actual input signal whenever respect IMD $\leq 20\%$ . Typical or average measurement setting time is 2 sec or less
	CCIF difference tone test Frequency range Difference frequency range Residual IMD ( $V_m$ ) $\geq 250$ mV, $T \pm 40^\circ\text{C}$ .	Useable from 3 kHz to beyond 100 kHz. 50 Hz to 250 Hz. 1:1 to 4:1 (lower:upper) System specification with any SG 5010 oscillator or passively summed SG 505 oscillator pair.

400 Hz high pass 80 kHz low pass Audio bandpass	-3 dB at 400 Hz, $\pm 5\%$ ; at least -40 dB rejection at 60 Hz	3 pole Butterworth response
	-3 dB at 80 kHz, $\pm 5\%$ -3 dB at 22.4 Hz, $\pm 5\%$ and 22.4 kHz, $\pm 5\%$	3 pole Butterworth response

FILTERS	400 Hz high pass	3 pole Butterworth response
	80 kHz low pass	3 pole Butterworth response

Accuracy	Minimum input level	60 mV (-22 dBm)
	Residual IMD ( $V_m$ ) $\geq 250$ mV, $T \pm 40^\circ\text{C}$ .	$\leq 0.0018\%$ (-95 dB) with 14 kHz and 15 kHz test tones.

Accuracy	Within $\pm 10\%$ ( $\pm 1$ dB) for IM components $\leq 1$ kHz	Autorangeing % or dB modes only. Accuracy may also be limited by the effects of residual IMD and filter selection.
	400 Hz high pass	3 pole Butterworth response

A weighting (standard instrument only)	Within specifications for type 1 sound level meters listed in ANSI S 1.4 1971 (revised 1976) and IEC Recommendation 179.	Within specifications of CCIR Recommendation 468-2 and DIN 45405 for noise measurements with quasi-peak detector. Rms detector calibration shifted for 0 dB at 2.00 kHz instead of 1.00 kHz.
	CCIR WTG (Option 02 only)	Within specifications of CCIR Recommendation 468-2 and DIN 45405 for noise measurements with quasi-peak detector. Rms detector calibration shifted for 0 dB at 2.00 kHz instead of 1.00 kHz.

External Filter

Selects front panel AUXILIARY INPUT  
allowing connection of external filter between  
it and FUNCTION OUTPUT.





Characteristics	Performance Requirement	Supplemental Information
<b>FRONT PANEL SIGNALS</b> INPUT MONITOR $V_n \geq 50$ mV $V_n < 50$ mV Impedance	1 V rms, $\pm 10\%$ 1 k $\Omega$ , $\pm 5\%$	Constant amplitude (average response) version of differential input signal. THD is typically $\leq 0.0010\%$ (-100 dB) from 20 Hz to 20 kHz. Approximately 20 times input signal.
<b>FUNCTION OUTPUT</b> Signal Impedance	1 V, $\pm 3\%$ , for 1000 count volts or % display 1 k $\Omega$ , $\pm 5\%$	Selected and filtered ac signal actually measured.
<b>AUXILIARY INPUT</b> Sensitivity Maximum Input Voltage Impedance	1 V, $\pm 3\%$ , for 1000 count volts or % display 100 k $\Omega$ , $\pm 5\%$	Loop through accuracy from FUNCTION OUTPUT is $\pm 3\%$ . 15 V peak, 6 V peak for linear response. Ac coupled.
<b>REAR INTERFACE SIGNALS</b> Rear interface input	Pins 28B (+), 28A (-), 27B and 27A (common) are front panel selectable and independent of main front panel input. All characteristics are the same as main INPUT except maximum input voltage is limited to 42 V peak, 30 V rms. Due to potential crosstalk at the rear interface, noise and distortion performance may be degraded.	Pins 24A and 23A (gnd) same as front panel FUNCTION OUTPUT. Pins 23B and 24B (gnd) same as front panel FUNCTION OUTPUT.
Input monitor	Pins 24A and 23A (gnd) same as front panel FUNCTION OUTPUT.	Pins 24A and 23A (gnd) same as front panel FUNCTION OUTPUT.
Function output	Pins 23B and 24B (gnd) same as front panel FUNCTION OUTPUT.	Pins 23B and 24B (gnd) same as front panel FUNCTION OUTPUT.
Auxiliary input	Pins 25B and 26B (gnd) same as front panel AUXILIARY INPUT. Maximum input voltage is 15 V peak, 6 V peak for linear operation.	Pins 25B and 26B (gnd) same as front panel AUXILIARY INPUT. Maximum input voltage is 15 V peak, 6 V peak for linear operation.
AC/DC Converter output	Pins 20A and 19A (gnd). Dc output of the selected ac to dc converter, 1 V $\pm 5\%$ for 1000 count display with 500 $\Omega$ $\pm 5\%$ source resistance.	Pins 20A and 19A (gnd). Dc output of the selected ac to dc converter, 1 V $\pm 5\%$ for 1000 count display with 500 $\Omega$ $\pm 5\%$ source resistance.
dB converter output	Pins 19B and 20B (gnd). Dc output of the logarithmic dB converter, 10 mV $\pm 5\%$ equals 1 dB of display with 2 k $\Omega$ $\pm 5\%$ source resistance. Changes in level or distortion range will cause brief ac transients.	Pins 19B and 20B (gnd). Dc output of the logarithmic dB converter, 10 mV $\pm 5\%$ equals 1 dB of display with 2 k $\Omega$ $\pm 5\%$ source resistance. Changes in level or distortion range will cause brief ac transients.

Table 1-1 (cont)



Table 1-1 (cont)

Characteristics	Performance Requirement	Supplemental Information
DETECTORS AND DISPLAYS Detectors (Response) RMS AVG (standard instrument only)		True rms detection. Average detection, rms calibrated for sine waves. Typically reads 1 to 2 dB lower than true rms detection for noise, THD + and IMD measurements.
Quasi-peak (Option 02 only)		Quasi-peak detection, rms calibrated for sine waves. Within specifications of CCIR Recommendation 468-2 and DIN 45405. Do not to the peak hold nature of its response readings, considerably higher than rms response will occur with large crest factor signals (such as noise). The input range indicators should be ignored and auto-ranging avoided with these types of signals
Displays Digital Analog bar graph		3-1/2 digit, 2000 count LED. Overrange indication is 1, blank, blank, blank. 10 segment LED intensity modulated bar graph display of digital readout. Segments are logarithmically activated with approximately 2.5 dB/segment.
MISCELLANEOUS Power consumption		Approximately 24 watts
Internal Power Supplies +15 -15 +5		Nominally +15.1 V, ±3% Nominally -15 V, ±5% Nominally +5.25 V, ±2%
Fuse Data F1610 F1620 F1621		3 AG, 1 A, 250 V, fast blow 3 AG, 1 A, 250 V, fast blow 3 AG, 1 A, 250 V, fast blow
Recommended adjustment interval		2000 hours or 12 months whichever occurs first.
Warm-up time		20 minutes (60 minutes after storage in high humidity environment).

\*±0.2 dB at 1 kHz only. Flatness is ±0.1 dB, 20 Hz to 20 kHz, and ±0.3 dB, 10 Hz to 100 kHz.



Table 1-2 ENVIRONMENTAL CHARACTERISTICS

Characteristics		Description
Temperature	Operating Nonoperating	Meets MIL-T-28800B, class 5.
Humidity	95% RH, 0 to $\pm 30^\circ\text{C}$ 75% RH to $\pm 40^\circ\text{C}$ 45% RH to $\pm 50^\circ\text{C}$	Meets MIL-T-28800B, class 5.
Altitude	Operating Nonoperating	Exceeds MIL-T-28800B, class 5.
Vibration	0.38 mm (0.015") peak to peak, 5 Hz to 55 Hz, 75 minutes	Meets MIL-T-28800B, class 5, when installed in qualified power modules.
Shock	30 g's (1/2 sine), 11 ms duration, 3 axes, 18 total shocks	Meets MIL-T-28800B, class 5, when installed in qualified power modules.
Bench Handling	12 drops from 45", 4" or equilibrium, whichever occurs first.	Meets MIL-T-28800B, class 5.
Package Product Vibration and Shock (Plug-in only)	Qualified under National Safe Transit Association Preshipment Test Procedure 1A-B-1 and 1A-B-2.	
Electromagnetic Interference	Within limits of F.C.C. Regulations, Part 15, Subpart J, Class A; and MIL-STD-461B (April 1, 1980) Class B.	
Electrostatic Immunity	At least 15 kV discharge from 500 pF in series with 100 $\Omega$ to instrument case or any front panel connector without damage or permanent performance degradation (input terminals limited to 10 kV).	

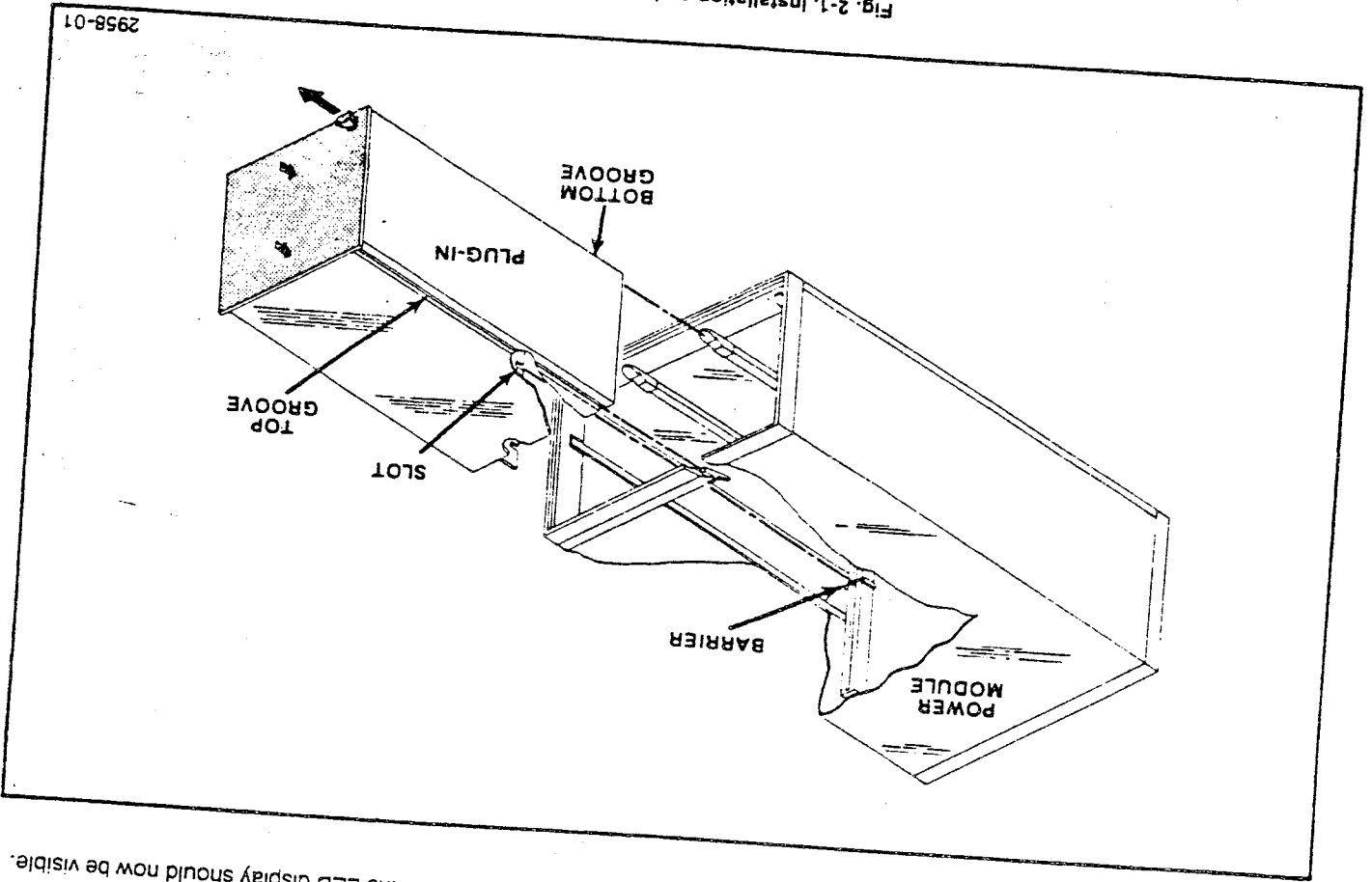
\*With TM 5000-Series power module. System performance subject to exceptions of power module or other individual plug-ins. Refer to power module specifications. Requires power module retainer bar or clip.

Table 1-3 PHYSICAL CHARACTERISTICS

Characteristics		Description
Maximum Overall Dimensions	Height Width Length	126.0 mm (4.96 inches) 131.2 mm (5.16 inches) 285.5 mm (11.24 inches)
Net Weight		Approximately equal to 2.04 kg (4.5 lbs.)
Finish	Front Panel Chassis	Plastic-aluminum laminate Anodized aluminum



Fig. 2-1. Installation and removal.



Preparation For Use

The AA 5001 is calibrated and ready for use when received. It operates in any two compartments of a TM 5000-Series power module. See the power module instruction manual for line voltage requirements and power module operation. Figure 2-1 shows the AA 5001 installation and removal procedure.

Check to see that the plastic barriers on the interconnecting jack of the selected power module compartment match the cutouts in the AA 5001 circuit board edge connector. Align the AA 5001 chassis with the upper and lower guides of the selected compartment. Press the AA 5001 in, to firmly seat the circuit board in the interconnecting jack.

**CAUTION**

Turn the power module off before inserting the AA 5001. Otherwise, arcing may occur at the rear interface connectors, reducing their useful life and damage may result to the plug-in circuitry.

To remove the AA 5001 pull the release latch (located in the lower left corner) until the interconnecting jack disengages and the AA 5001 slides out.

Check that the AA 5001 is fully inserted in the power module. Push the power switch on the power module. One or more characters in the LED display should now be visible.

# OPERATING INSTRUCTIONS





Operating Instructions—AA 5001

NOTE

The AA 5001 can be operated via the front panel or by commands sent over the GPIB by a suitable controller. This section discusses front panel operation. See the Programming section of this manual for instrument operation via the GPIB.

Repackaging Information

If the Tektronix instrument is to be shipped to a Tektronix Service Center for service or repair, attach a tag showing the owner (with address) and the name of an individual at your firm that can be contacted. Include the complete instrument serial number and a description of the service required.

Save and reuse the package in which your instrument was shipped. If the original packaging is unfit for use or not available, repack the instrument as follows:

Surround the instrument with polyethylene sheeting to protect the finish of the instrument. Obtain a carton of corrugated cardboard of the correct carton strength and having inside dimensions of no less than six inches more than the instrument dimensions. Cushion the instrument by tightly packing three inches of dunnage or urethane foam between carton and instrument on all sides. Seal the carton with shipping tape or an industrial stapler.

The carton test strength for this instrument is 200 pounds per square inch.

Controls, Connectors, and Indicators

All controls, connectors and indicators (except for the rear interface connector) required for operation of the AA 5001 are located on the front panel. Fig. 2-2 provides a brief description of all front panel controls, connectors, and indicators.

1 INPUT RANGE

Selects input voltage range or AUTORANGE. The three most sensitive ranges operate in the LEVEL FUNCTION only. (The AA 5001 goes to AUTORANGE when in a remote state.)

2 DECREASE RANGE

When this light is illuminated, reduce the INPUT LEVEL RANGE until the light goes out. If the FUNCTION selected is THD+N or IMD a flashing light indicates insufficient input signal level for distortion measurements.

3 INCREASE RANGE

When this light is illuminated, increase the INPUT LEVEL RANGE until the light goes out.

4 INPUT MONITOR

Differential input terminal. Positive going input signal provides positive going output at INPUT MONITOR.

5 INPUT MONITOR

Differential input terminal. Negative going input signal provides positive going output at INPUT MONITOR.

6 Release Latch

7 LEVEL

Button in selects input level measuring function.

8 VOLTS

Button in selects voltage units for level function.

9 dBm 600 Ω

Button in selects dBm units for level function. 0 dB reference is 0.7746 V corresponding to 1 mW into 600 Ω.

10 DB RATIO

Button in selects dB ratio, with respect to preset level, as units for level function.

11 PUSH TO SET 0 DB REF

Push button to set display to 0 with input signal applied to INPUT terminals in LEVEL function. dB RA-TIO and LEVEL pushbuttons must be in for this feature to operate.

12 REAR INTFC-INPUT

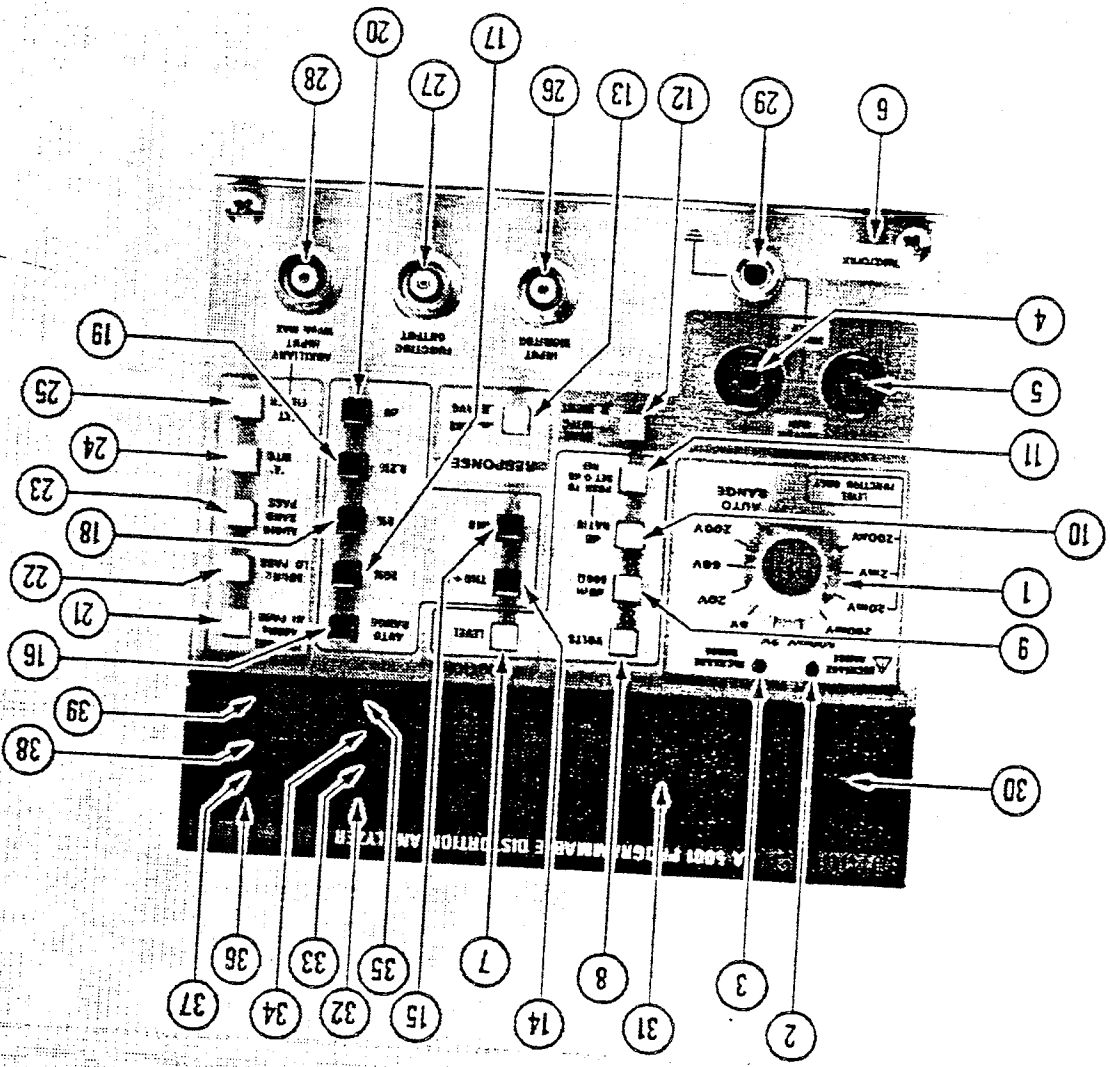
Button in selects rear interface input; button out selects front panel input.

13 RESPONSE

Button in gives RMS detection (responds to the rms value of the input waveform). Button out gives average detection or quasi-peak detection (option 02 instruments) both are rms calibrated for sine waves.



Fig. 2-2. Front panel controls and connectors.



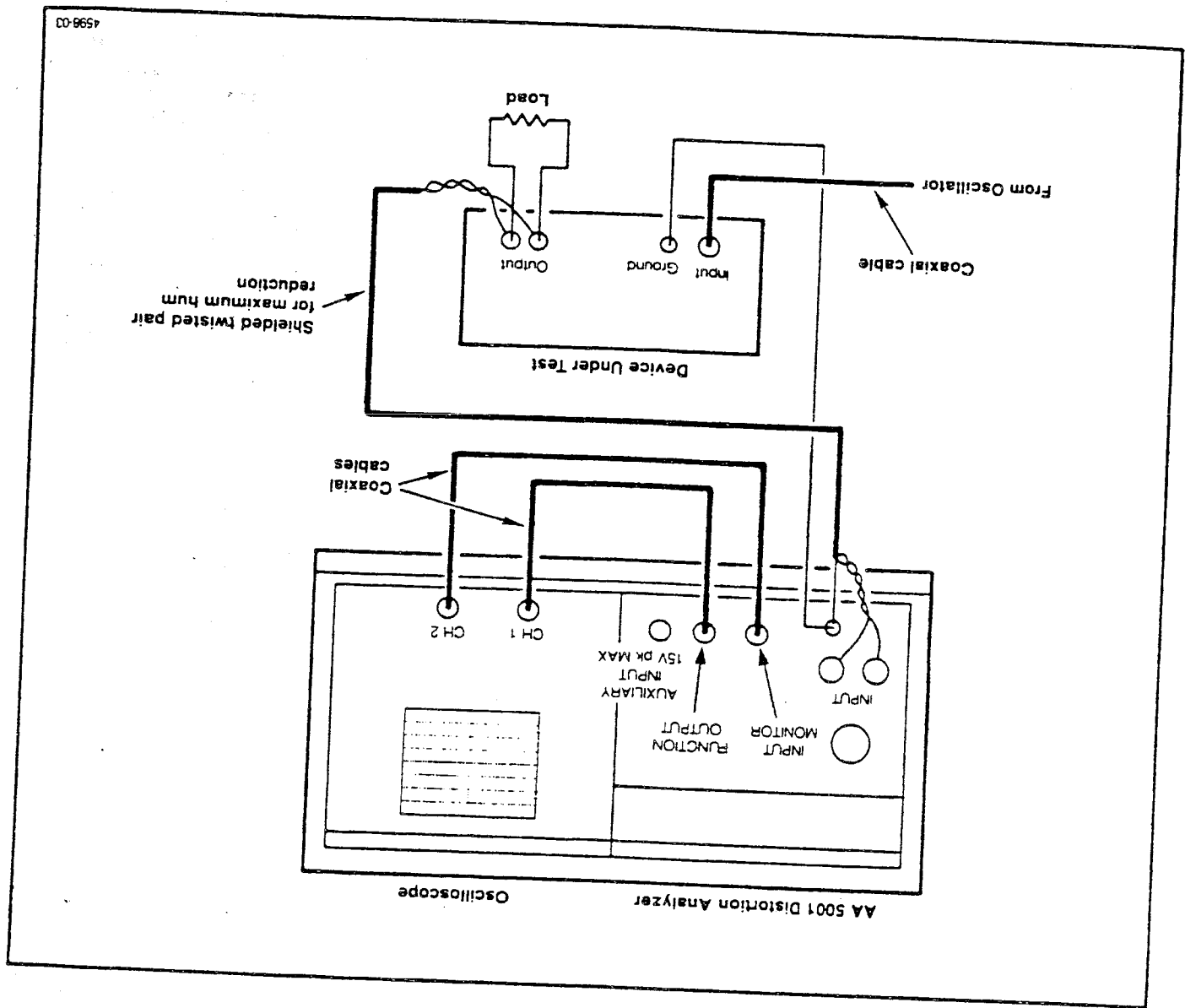


- 26 INPUT MONITOR Provides a buffered sample of the input signal.
- 27 FUNCTION OUTPUT Provides a sample of the selected FUNCTION signal additionally processed by selected filters.
- 28 AUXILIARY INPUT Provides input to the detector circuit when the EXT FILTER button is pressed.
- 29 Ground Provides front panel chassis ground connection.
- 30 LED Bar Graph Provides approximate analog display of the digital display for nulling and peaking. Each segment represents approximately 2.5 dB.
- 31 Digital Display 3-1/2 digits. Overrange indication is a blanked digit play with the numeral 1 in the most significant digit position.
- 32 V Illuminated when display units are volts.
- 33 mV Illuminated when display units are millivolts.
- 34  $\mu$ V Illuminated when display units are microvolts.
- 35 % Illuminated when display units are percent.
- 36 RMT Illuminated when the AA 5001 is in the remote state or the remote with lockout state.
- 37 ADPS Illuminated when the AA 5001 is talk or listen addressed.
- 38 dBm Illuminated when display units are dBm.

- 14 THD+N Button in selects total harmonic distortion function.
- 15 IMD Button in selects intermodulation distortion function.
- 16 AUTO RANGE Button in selects automatic distortion range selection (0.2% to 100% full scale). (The AA 5001 goes to AUTORANGE when in a remote state.)
- 17 20% Button in selects full scale distortion readout of 20% with 0.01% resolution.
- 18 2% Button in selects full scale distortion readout of 2% with 0.001% resolution.
- 19 0.2% Button in selects full scale distortion readout of 0.2% with 0.0001% resolution.
- 20 dB Selects single equivalent 0 dB to -100 dB distortion display range with 0.1 dB resolution.
- 21 400 Hz HI PASS Button in connects filter before detector circuit in all functions.
- 22 80 KHz LO PASS Button in connects filter before detector circuit in all functions.
- 23 AUDIO BANDPASS Button in connects filter before detector circuit in all functions.
- 24 'A' WEIGHTING (CCIR WEIGHTING in Option 02 Instruments) Button in connects filter before detector circuit in all functions.
- 25 EXT FILTER Button in allows connection of external filter between FUNCTION OUTPUT and AUXILIARY INPUT in all functions.



Fig. 2-3. Typical connections for distortion measurements.



Instrument Connections

To make connections to the AA 5001, refer to Fig. 2-3. Connections can be made to the rear interface connector. However, low level or distortion measurements made through the rear interface may be degraded due to crosstalk. To measure signals connected to the front panel make certain the INPUT pushbutton is out. To select the rear interface signal input press the INPUT pushbutton.

illuminated when display units are dB.

39 dB

CAUTION

Maximum front panel input voltage is 300 V peak, 200 V rms either input to ground or differentially. Maximum rear interface input is 42 V peak and 30 V rms. The AA 5001 input circuitry is protected against accidental overloading. This circuitry will recover without damage from continuous 120 V rms (30 minutes at 200 V rms) overloads in any INPUT RANGE setting.





In most cases, for maximum hum rejection, follow the cabling and grounding as shown in the figure. Shielded, twisted pair offers maximum hum and radio frequency interference rejection. Cable shielding, if used, should be grounded only at the AA 5001 front panel ground post. Use shielded cable to connect the output of an oscillator, external to the device under test, to the input of the device. Generally, to avoid possible ground loops, if the device under test has one side of the input grounded, float the output of the external oscillator. If the input to the device under test is floating (not chassis grounded) select the grounded mode for the output of the oscillator. Terminate the output of the device under test in its recommended load impedance, or the load impedance specified in the appropriate standard.

Figure 2-3 shows an optional oscilloscope for visual monitoring. If connected as shown, channel 1 displays a sample of the input signal and channel 2 displays the distortion components when in the IM or THD + N function.

### Level Measurements

In the LEVEL function the AA 5001 operates as a wide band ac voltmeter. The Specification section of this manual contains the operating parameters. The meter is rms calibrated and either rms or average (quasi-peak in option 02 RESPONSE pushbutton, depending on the position of the RESPONSE pushbutton).

Press the FUNCTION LEVEL pushbutton. The top three readout units as VOLTS, dBm 600  $\Omega$ , or dB RATIO. For example, to measure voltage, press the VOLTS pushbutton. If the INCREASE RANGE LED is illuminated, adjust the INPUT LEVEL RANGE control to the higher ranges until the LED goes out. (With the AA 5001 in the remote state, the INPUT RANGE automatically goes to the AUTO RANGE position irrespective of the actual switch position.) If the DECREASE RANGE LED is illuminated, turn the INPUT RANGE control counterclockwise until the DECREASE RANGE LED goes out. Readings are usable as long as the display is not overranged however for specified accuracy the DECREASE RANGE LED must also be off. Overrange is indicated by a blank display with the numeral 1 in the most significant digit slot.

If the INPUT LEVEL RANGE switch is placed in the AUTO RANGE position, the input level is adjusted automatically. The LED's (VOLTS, MVOLTS or UVOLTS) automatically illuminate showing the proper display units. Notice that the three most sensitive ranges on the INPUT LEVEL RANGE control operate in the LEVEL FUNCTION only.

When the dBm 600  $\Omega$  pushbutton is pressed, the LED opposite dBm on the display indicates the display units. The

The dB RATIO mode permits direct amplitude ratio measurements of two input signals. When the dB RATIO pushbutton is pressed, the LED opposite the dB nomenclature on the display illuminates. To use this feature, press the RATIO pushbutton. To establish the input signal as 0 dB reference, push the PUSH TO SET 0 dB REF pushbutton and notice that the display reads all zeros. Release the 0 dB REF pushbutton. As the amplitude of the input signal changed, the display reads the dB ratio of the input signal to the reference signal amplitudes.

There are many useful applications for the dB RATIO mode in measurements of gain-loss, frequency response, S/N ratio, etc. For example, the corner frequency of a filter may be quickly checked. Set the test frequency to some midband value and set the zero dB reference. Adjust the test frequency until the display reads -3.0 dB; this is the corner frequency of the filter.

Gain measurements may be simplified by using this feature. Set the device to be tested as desired and connect the AA 5001 input to the input of the device under test. Press the PUSH TO SET 0 dB REF pushbutton. Then connect the input of the AA 5001 to the device output and read the gain or loss directly from the display.

When measuring signal to noise ratio or making noise level measurements, it is often desirable to employ a frequency dependent weighting network. The AA 5001 provides several internal filters, as well as facilities for connecting external filters. For information on their operation and use, see the text under Filters in this section of this manual.

### Distortion Measurements

Distortion is a measure of signal impurity. It is usually expressed as a percentage or dB ratio of the undesired components to the desired components. Harmonic distortion is simply the presence of harmonically related or integral multiples of a single pure tone called the fundamental, and can be expressed for each particular harmonic. Total harmonic distortion, or THD, expresses the ratio of the total power in all significant harmonics to that in the fundamental.

A distortion analyzer removes the fundamental of the signal investigated and measures the remainder. See Fig. 2-4. Because of the notch filter response, any signal other than the fundamental influences the measurement.



### IM Distortion Measurements

Another measurement of distortion investigates the interaction of two or more signals. Many tests have been devised to measure this interaction. Three common standards are SMPTE<sup>3</sup>, DIN<sup>4</sup>, and CCIF<sup>5</sup>. The AA 5001 is capable of automatically selecting and performing all three tests.

To measure intermodulation distortion (IM), according to SMPTE and DIN standards, the device under test is excited with a low frequency and high frequency signal simultaneously (Fig. 2-7). The output signal is high-pass filtered to remove the low frequency component. The high frequency tone is then demodulated, as an AM radio signal. The demodulator output is low-pass filtered to remove the residual carrier (high frequency) components. The amplitude of the low frequency modulation is displayed as a percentage of the high frequency level.

As shown in Fig. 2-8, when this composite signal is applied to the device, the output waveform is distorted. As the high frequency tone is moved along the transfer characteristics by the low frequency tone, its amplitude changes. This results in low frequency amplitude modulation of the high frequency domain as sidebands around the high frequency tone. The power in these sidebands represents nonlinearity in the device under test.

The amplitude ratio of low to high frequencies should be between 4:1 and 1:1. The AA 5001 circuitry automatically adjusts calibration to compensate for the selected test signal ratio. Some additional range is provided in this circuitry to enable measurement of devices with nonflat frequency response.

SMPTE standard test frequencies are 60 Hz and 7 kHz. The DIN standard is virtually identical to the SMPTE standard except for the two frequencies used. They may be any pair of octave band center frequencies, with the upper at least eight times as high as the lower (250 Hz and 8 kHz are most common). The AA 5001 can accept a wide range of test frequencies as shown in the Specification section.

<sup>3</sup>Society of Motion Picture and Television Engineers, Standard No. TH 22.51, 862 Scarsdale Avenue, Scarsdale, N.Y. 10583.  
<sup>4</sup>Deutsches Institut für Normung e V, No. 45403 Blatt 3 and 4, January 1975, Beuth Verlag GmbH, Berlin 30 and Köln 1.  
<sup>5</sup>International Telephone Consultative Committee.

When making distortion measurements, the RESPONSE button should normally be in the RMS position. Current distortion measurement standards require the use of rms reading instruments by specifying power summation of each of the components. The AVG response may be used when making comparisons with readings taken with older distortion analyzers. However, it may read up to 25% (2 dB) lower than rms response when noise is significant and even lower with high crest factor distortion signals (characteristic of crossover or hard-clipping non-linearities).

For frequencies below 20 kHz, the residual wideband noise in the measurement may be reduced by activating the 80 kHz LO PASS filter. If hum (line related components) are interfering with the measurement, they may be reduced with the 400 Hz HI PASS filter. This filter should not be employed with fundamental frequencies below approximately 400 Hz because of additional error due to rolloff. For more information see text under Filters in this section of this manual.

### High Distortion Measurement Limitations

#### NOTE

Care must be taken to ensure proper locking for input signals with 10% or greater noise or non-harmonic components, because the AA 5001 automatically tunes and nulls out the fundamental frequency prior to making a THD+N measurement.

In those applications which require higher THD+N measurements (for example, SINAD<sup>2</sup> testing) the internal circuitry will remain locked to noise levels of approximately 30%, after it is initially given a clean signal. To perform a SINAD test, the receiver under test is first given a high level modulated  $r$  input. The AA 5001 will lock onto the audio signal at the demodulated output. The  $r$  level feeding the receiver is then reduced until a  $-12$  dB (25%) THD+N reading is obtained on the AA 5001 and becomes a measure of the receiver's sensitivity.

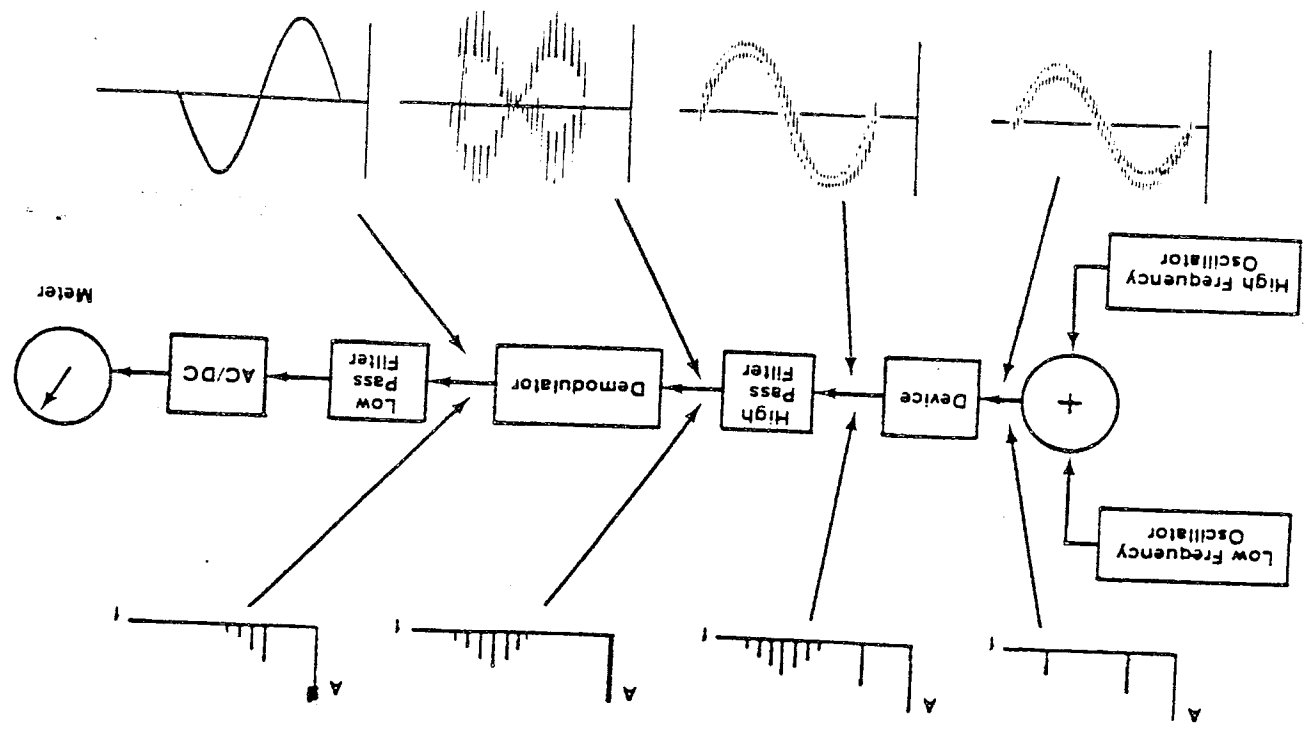
<sup>2</sup>Defined in Electronic Industries Association Standard No. RS 204A, July 1972, Electronic Industries Association, Engineering Department, 2001 Eye St. N.W., Washington, D.C. 20006.



To measure two tone difference frequency distortion the device is excited with two input signals as described above. The output of the device is low-pass filtered to remove the two test tones and extract the difference frequency product. The level of this component is expressed as a percentage of the high frequency signals. The AA 5001 CClF difference

CClF difference frequency distortion is measured with two high frequency sine waves driving the device under test. Both are of equal level and closely spaced in frequency. Nonlinearities in the device under test cause the sine waves to cross modulate. This creates new signals at various sum and difference frequencies from the inputs. For example, the commonly used 14 kHz and 15 kHz test frequencies produce 1 kHz, 13 kHz, 14 kHz, 15 kHz, 16 kHz, 28 kHz, etc. The user could measure each new component with a tunable filter such as a spectrum analyzer; however, this is usually limited to an 80 dB dynamic range and is very tedious. In many systems and especially those with asymmetric non-linearities, a good measure of this distortion may be obtained by investigating only the difference frequency (in this example 1 kHz). If only the low frequency component is measured, it is called a CClF second order difference frequency distortion test.

Fig. 2-7. Block diagram of basic IM analyzer.



2958-06

**IM Distortion Measurement Procedure**

Intermodulation and THD testing are similar, using the AA 5001. After connecting the appropriate signal source to the device under test, set the INPUT RANGE as described in the THD section. Press the IMD FUNCTION button and select a distortion range. Selecting AUTO RANGE or dB provides automatic ranging. The AA 5001 accepts either a SMPTE, DIN, or a CClF difference frequency test signal. Selection between the necessary analyzing circuits is accomplished automatically for IMD levels less than 20%, based upon the spectral content of the test tones. (There is a moveable jumper inside the AA 5001 to allow defeating the automatic test selection circuitry for special applications requiring IMD measurements in excess of 20%. Refer any jumper changes to qualified service personnel.)

The LO PASS and BAND PASS filters may be selected in the IM mode but will have little or no effect. The 400 Hz HI PASS and the WEIGHTING filters will cause erroneous readings because the IM components of interest generated by the tests fall between 50 Hz and 1 kHz. These filters

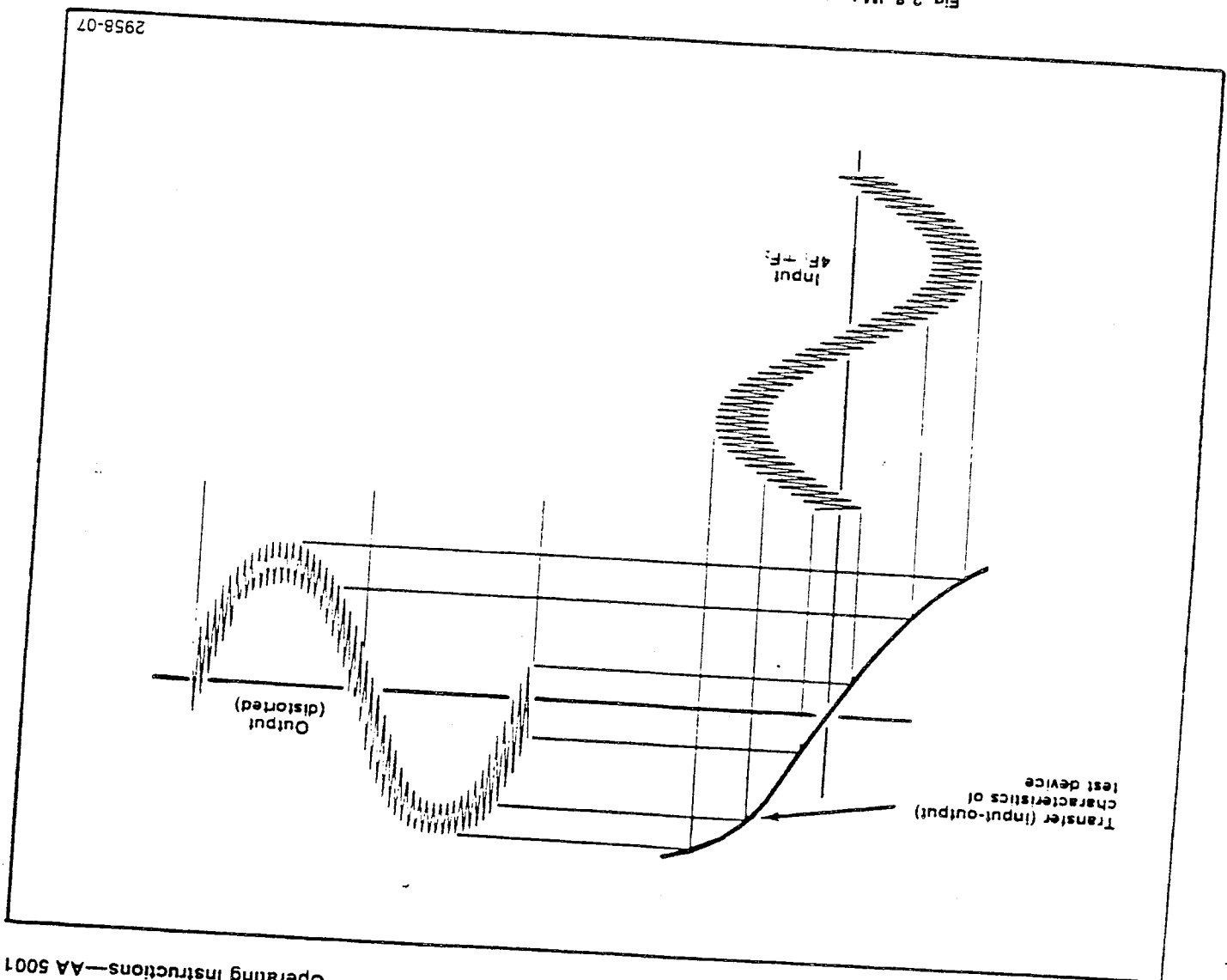


The five buttons along the right edge of the instrument allow selection of four built-in frequency weighting filters plus an external filter, as desired. See Fig. 2-9 for response curves of the various filters. The 400 Hz, and 80 kHz filters are both 3-pole (18 dB per octave rolloff) Butterworth alignment. The AUDIO BAND PASS filter follows CCIR Recommendation 468-26 for unweighted response. It is approximately two pole response below the lower 3 dB point of 22.4 Hz and three pole response above the upper 3 dB point of 22.4 kHz. They are placed in the measuring circuitry immediately before the average or rms detectors. These filters are functional in all modes of operation. They also affect the signal at the FUNCTION OUTPUT connector.

**Filters**

when activated in the IM mode may attenuate some of the frequency components being measured and should be avoided.

Fig. 2-8. IM test of transfer characteristics in time and frequency domain.



The 400 Hz HI PASS filter is used to reduce the effects of hum on the measurement. Although the differential input and common mode rejection of the AA 5001 reduce the effects of ground loops, extremely bad measurement conditions may require use of this filter. The device under test may also generate an undesirable amount of hum, limiting the noise and distortion residuals obtainable. This filter may be used when measuring harmonic distortion of signals at about 400 Hz or greater, but should not be used when mea-

Check the position of all filter pushbuttons before making measurements, to prevent inaccurate results. Filtering takes place after all gain circuits. Therefore, it is possible to overload part of the instrument, when operating in the manual distortion ranges with a filter selected, even though the display is not overranged. This may be checked by releasing the filter pushbuttons and checking the display for over-range or by pressing the AUTO RANGE pushbutton.



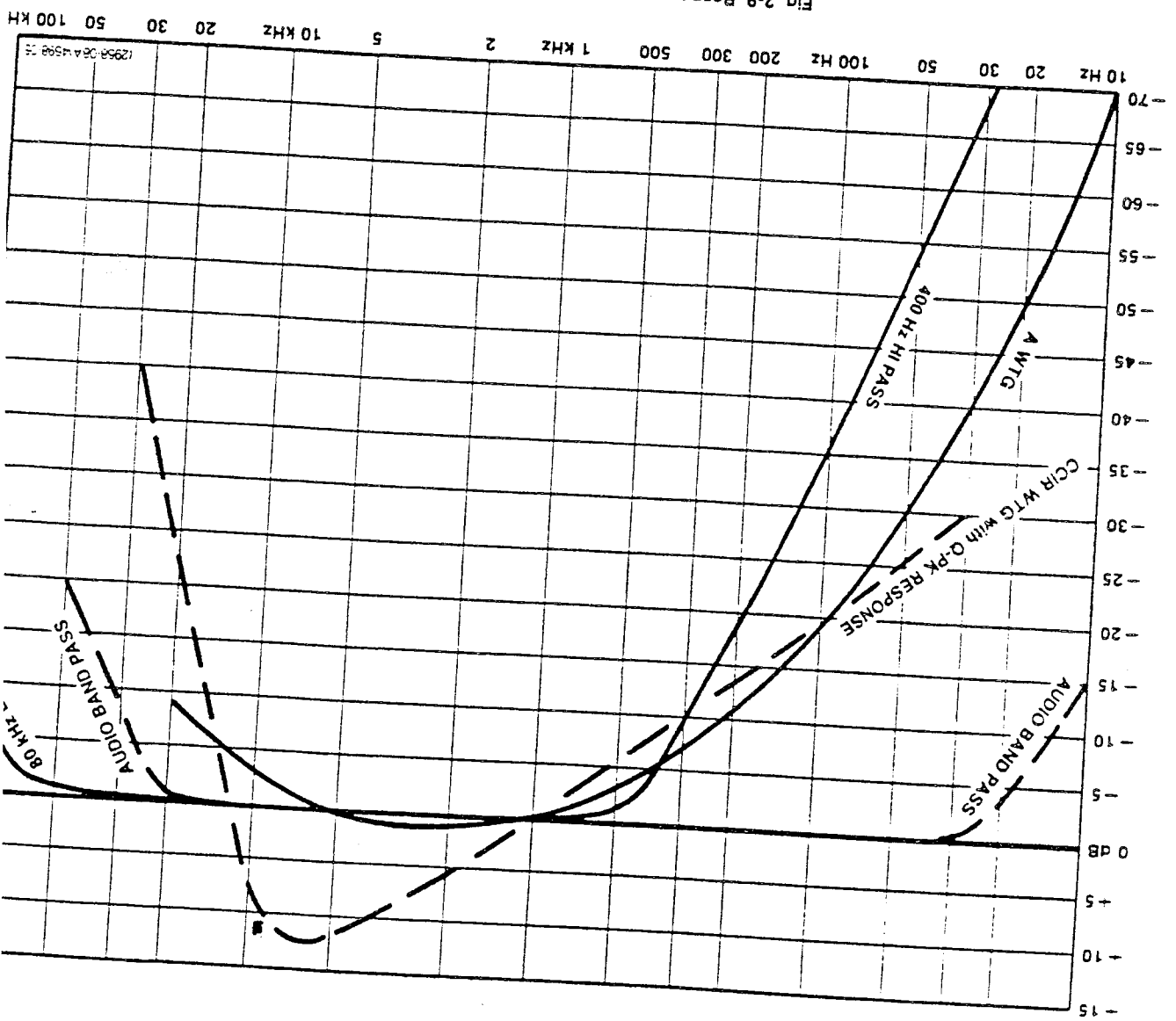


Use of the 80 kHz LO PASS filter reduces the effects of wideband noise and permits measurement of lower THD + N for input signals up to 20 kHz. For 20 kHz inputs, do not use this filter if harmonic components above 80 kHz are of interest. When checking noise, the 80 kHz filter may be used to reduce the measurement bandwidth. However, for most noise measurements, the AUDIO BANDPASS or WEIGHTING filters are recommended as they correlate better with the perceived noise level.

The AUDIO BAND PASS filter provides bandwidth limiting according to CCIR Recommendation 468-2 and DIN 45405. It is also useful for unweighted measurements on certain acoustic equipment. When the AUDIO BAND PASS filter is used, the 80 kHz filter is disabled. It may be desirable to modify the high frequency cutoff of the AUDIO BAND PASS filter to 30 kHz for certain broadcast proof of performance testing or as desired for other special purposes. This may be performed by qualified service personnel as described in the Service section of this manual.

Operating instructions—AA 5001

Fig. 2-9. Response curves for AA 5001 filters.





**Monitoring**

The interface capabilities of the AA 5001 may aid considerably in the interpretation of measurements.

The INPUT MONITOR connector provides a fixed amplitude version (approximately equal to 1 V rms) of the input signal for input signals of 50 mV or greater. This allows display of the input signal on an oscilloscope, without constantly readjusting the oscilloscope sensitivity. At input levels below about 50 mV the INPUT MONITOR signal is approximately 26 dB (gain of approximately equal to 20) above the input signal level.

The FUNCTION OUTPUT is taken after the distortion measurement and high gain amplifier circuitry. It can be used for monitoring the signal read on the display. The signal at the FUNCTION OUTPUT connector is 2 V for a full scale reading on the display. In the level function this connector becomes an amplified version of the input signal. The gain from the input to this output is dependent on the LEVEL RANGE switch, and is given in Table 2-1. When the AA 5001 is used as a constant gain differential amplifier the INPUT RANGE switch must be set to a fixed range. In the distortion function this output can be displayed on an oscilloscope to view the distortion components. This output may also be used to drive a spectrum analyzer or selective voltmeter for examining the individual harmonics or modulation products. When an oscilloscope is used, the triggering signal is best taken from the sync output on the oscillator. If this is not possible (for example in tape recorder or Telco link testing) it should be obtained from the INPUT MONITOR connector on the AA 5001.

For rapid nulling or peaking applications, the digital display is supplemented by an uncalibrated LED bar graph for an analog meter-like display. The bar graph responds logarithmically, with each segment representing approximately a 2.5 dB change in the selected function. Additionally, the intensity of the segments is modulated between steps permitting resolution of changes as small as 0.5 dB. The range of the bar graph is determined by the measurement range in use. When using this feature it may be desirable to select a manual range to prevent confusing displays caused by autoranging.

The A weighting filter (standard instruments only) is used when measuring the subjective noise of audio equipment. It conforms to the noise measurement standards of the Institute of High Fidelity (IHF). The filter shape is within ANSI, DIN, and IEC standards for class 1 sound level meters.

The CCIR weighting filter (option 02 instruments only) is also used when measuring the subjective noise of audio equipment, however it conforms to CCIR Recommendation 468-2 and DIN 45405 when used with the quasi-peak detector response. This filter may also be used with the rms detector, however the gain calibration is shifted for unity gain at 2.0 kHz instead of 1.0 kHz permitting noise measurements similar to those proposed by Dolby et al on tape recording and playback systems.

Connections for an external filter are also provided. Press the EXT FILTER pushbutton. Connect the external filter between the FUNCTION OUTPUT and the AUXILIARY INPUT. One application for the external filter is selective measurement of individual harmonics or components of an input signal. This may be accomplished using a unity gain bandpass filter as an external filter, and adjusting the frequency to the harmonic desired.

**Displays**

The AA 5001 provides two display forms for manual measurements. The digital readout displays the selected function with units. Overrange indication blanks all digits and displays a numeral 1 in the most significant digit slot.

For rapid nulling or peaking applications, the digital display is supplemented by an uncalibrated LED bar graph for an analog meter-like display. The bar graph responds logarithmically, with each segment representing approximately a 2.5 dB change in the selected function. Additionally, the intensity of the segments is modulated between steps permitting resolution of changes as small as 0.5 dB. The range of the bar graph is determined by the measurement range in use. When using this feature it may be desirable to select a manual range to prevent confusing displays caused by autoranging.

International Radio Consultative Committee.

International Electrotechnical Commission, Publication 179, second edition, Precision Sound Level Meters, 1973, Central Office of EIC (sales department), 1, rue de Varembe, 1211 Geneva 20 Switzerland.  
 Dolby et al, CCIR/ARM: A Practical Noise-Measurement Method, Journal of the Audio Engineering Society, Vol. 27, No. 3, March 1979, p. 149.  
 International Radio Consultative Committee.

LEVEL RANGE Setting	Gain to FUNCTION OUTPUT
200 V	-40 dB
60 V	-30 dB
20 V	-20 dB
6 V	-10 dB
2 V	0 dB
600 mV	+10 dB
200 mV	+20 dB
20 mV	+40 dB
2 mV	+60 dB
200 μV	+80 dB

Table 2-1  
 Gains from INPUT terminals to FUNCTION OUTPUT connector for various settings of the INPUT LEVEL RANGE control



One interesting use of the Function Output and Input Transfer function of a device under test with the THD+N mode. For this measurement, the FUNCTION OUTPUT drives the vertical input of an oscilloscope while the INPUT MONITOR drives the horizontal. The resulting display is similar to Fig. 2-10, and represents the deviation from linearity of the transfer characteristic. In other words, it represents the transfer characteristic after the best fit straight line is removed. This can be particularly useful in diagnosing sources of non-linearity such as clipping, crossover, etc. If the device under test has large amounts of phase shift at the test frequencies it may be necessary to introduce compensating phase shift into the horizontal channel. Since the FUNCTION OUTPUT is taken after the filters, they will affect the signal seen at this connector. The vertical scale is the deviation from the best fit line and is related to the distortion range and vertical sensitivity of the oscilloscope.

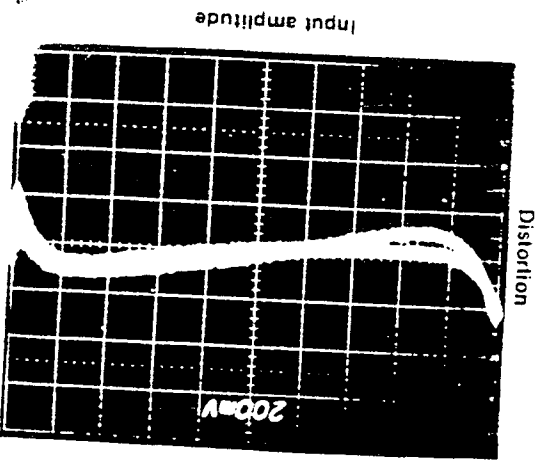


Fig. 2-10. Oscilloscope display of deviation from linearity.

2958-09



# PROGRAMMING

## Introduction

This section of the manual provides information for programming the AA 5001 by remote control via the digital interface. In this manual the digital interface is called the IEEE-488 General Purpose Interface Bus (GPIB). The following information assumes the reader is knowledgeable in GPIB communications and has some exposure to programming controllers. Communication via the GPIB is specified and described in the IEEE Standard 488-1978, Standard Digital Interface for Programmable Instrumentation™. TM 5000 instruments are designed to communicate with any GPIB-compatible controller that sends and receives ASCII messages (commands) over the GPIB. These commands program the instrument or request information from the instrument.

Commands for TM 5000 programmable instruments are designed for compatibility among instrument types. The same command is used in different instruments to control similar functions. In addition, commands are specified in mnemonics related to the functions they implement. For example, the command INIT initializes instrument settings to their power-up states.

## GPIB Address and Terminator Setting

The GPIB primary address for this instrument is set on the rear panel. The AA 5001 is shipped with the address set to decimal 28. The message terminators may also be selected. Message terminators are discussed in Messages and Communication Protocol (in this section). TM 5000 instruments are shipped with this terminator set to EOI ONLY. Refer qualified personnel to the Maintenance section of this manual for locations and setting information.

TM 5000 programmable instruments connect to the GPIB through a TM 5000 power module. Refer to the Operating Instructions section of this manual for information on installing the instrument in the power module. Also review this section to become familiar with front-panel and internally selectable instrument functions.

- A front panel illustration—showing command relationships to front panel operation. See Fig. 3-1.
- Instrument Command List—A list divided into functional groups with brief descriptions.
- Detailed Command List—An alphabetical listing of commands with complete descriptions.

Instrument commands are presented in three formats:









# COMMANDS

The commands for the AA 5001 can be classified in three categories:

**Setting Commands**—Control Instrument Settings

**Query-Output Commands**—Ask For Data

**Operational Commands**—Cause a particular action

The instrument responds to and executes all commands when in the remote state. In the local state setting and operational commands generate errors as the instrument is under front panel control. Only query-output commands are executed in this mode.

Each command begins with a header—a word that describes the function implemented. Many commands require an argument following the header—a word or number which specifies the desired state.

Brackets [] indicate the enclosed item is optional, and carets < > indicate a defined element. Capitalized letters are the required characters; the lower case letters may also be used.

## NOTE

## Instrument Commands

**Counts <num>**—Sets the display counts window for the setting algorithm.

**Counts?**—Returns the COUNTS setting.

**Dus [ON]**—Delays the SEND command until settled.

**Dus OFF**—Does not delay the SEND command until settled.

**Dus?**—Returns DUS ON or DUS OFF.

**ERRMSG?**—Same action as ERR? but includes a description string in the query response.

**ERROR?**—Returns the error code for the most recent error reported by serial poll when RQS is ON or the highest priority event when RQS is OFF.

**Event?**—Same action as ERR?

**[Filters] Bpass**—Enables bandpass filter.

**[Filters] External**—Enables external filter.

**[Filters] Flat**—Disables all filters.

**[Filters] Hpass**—Enables high pass filter.

**[Filters] Lpass**—Enables low pass filter.

**Filters OFF**—Disables all filters.

**[Filters] Wtg**—Enables weighting filter.

**Filters?**—Returns the state of all programmable filters.

**Fpsel**—Sets to front panel settings while under remote control.

**[Function] Dbm**—Selects level measurement in decibels relative to 0.775 volts.

**[Function] IMDDb**—Selects intermodulation distortion measurement in decibels.

**[Function] IMPct**—Selects intermodulation distortion measurement in percent.

**[Function] THDDb**—Selects total harmonic distortion measurement in decibels.

**[Function] THDPct**—Selects total harmonic distortion measurement in percent.



[Function] Volts—Selects level measurement in rms volts.

Function?—Returns the type of measurement selected.

HEIP?—Returns a list of command headers.

Identify?—Returns instrument identification and firmware version.

INIT—Returns instrument to initial settings.

OPC [ON]—Enables operation complete service request.

OPC OFF—Disables operation complete service request.

OPC?—Returns OPC ON or OPC OFF.

Over [ON]—Enables reporting of display overrange, insufficient input level, excessive input level and unsettled service requests.

Over OFF—Disables reporting of display overrange, insufficient input level, excessive input level and unsettled service requests.

Over?—Returns OVER ON or OVER OFF.

Points <num>—Sets the number of sample points for the setting algorithm.

Points?—Returns the POINTS setting.

Tolerance <num>—Sets the tolerance window for the setting algorithm in percent.

Tolerance?—Returns the TOLERANCE setting.

TEST?—Executes ROM test and returns 0 if test passes or 394 if test fails.

SETTINGS?—Returns all programmable settings.

SEND—Returns a measurement.

RQS?—Returns RQS ON or RQS OFF.

RQS OFF—Disables generation of service requests.

RQS [ON]—Enables generation of service requests.

Response?—Returns AVG (QPK for Option 02) or RMS response.

[Response] QPK—Selects quasi-peak response (Option 02 only).

[Response] RMS—Selects rms response.

[Response] AVE—Selects average response (standard instrument only).

[Response] AVG—Selects average response (standard instrument only).



# DETAILED COMMAND LIST

## NOTE

Brackets [ ] indicate the enclosed item is optional, and carets < > indicate a defined element. Capitalized letters are the required characters; the lower case letters may also be used.

### COUNTS

Type: Setting or Query

Setting Syntax: Counts < numeric >

Arguments: Any floating point value from 0 to 2000

Examples:

Counts 20  
Counts 4.5  
Counts 1.2E+2  
Counts 32.05E-2

Query Syntax: Counts?

Query Response: Counts < numeric >

Discussion:

The COUNTS command sets the settling algorithm window in units of display counts. Refer to SETTLING ALGORITHM in this section.

The COUNTS query returns the COUNTS setting.

The Power-up and INIT setting is COUNTS 2.0.

### COUNTS

Type: Setting or Query

Setting Syntax: DUS [ON]  
DUS OFF

Query Syntax: DUS?

Query Response: DUS ON;  
DUS OFF  
or  
DUS OFF

Discussion:

The DUS command tells the SEND command to delay sending a measurement until settling has occurred. Refer to SETTLING ALGORITHM and SEND in this section.

The Power-up and INIT setting is DUS ON.

### DUS (DELAY UNTIL SETTLED)





ERRMSG (ERROR MESSAGE)

Programming—AA 5001

Type:

Query only

Query Syntax:

ERRMSG?

Query Response:

ERRMSG <numeric>.<string>:

Example:

ERRMSG 0.'NO STATUS':

Discussion:

The ERRMSG? query has the same action as the ERROR? query except that a brief description string is included in the query response.

ERRMSG (ERROR MESSAGE)

ERROR

Type:

Query only

Query Syntax:

ERROR?

Query Response:

ERR <numeric>:

Discussion:

The ERROR? query is used to obtain information about the status of the instrument.

If RQS is ON, the ERROR? query returns an event code <number> describing why the RQS bit was set in the last Status Byte reported by the instrument. The event code is then reset to 0.

If RQS is OFF, the ERROR? query returns an event code <number> describing the highest priority condition currently pending in the instrument. This event code is then cleared and another ERROR? query will return the event code for the next highest priority condition pending.

ERROR



EVENT

FILTERS

A. WEIGHING is used on the standard instrument only. CCIR WEIGHING is used on Option 02 only. Refer to the OPERATING INSTRUCTIONS section.

NOTE

Each individual command enables the specified filter. FLAT and OFF disables all the filters.

Discussion:

FILT BP,EXT,HP;  
FILT FLAT;

Query Response:

Filters?  
Bpass?  
Flat?

Query Syntax:

Filt EXT  
Filt HP  
Filt OFF  
BP  
Flat  
HP ON  
HP OFF  
Filt Lp,Wtg,EXT

Examples:

Bpass  
External  
Flat  
Hpass  
Lpass  
Off  
Wtg

Arguments:

[Filters] <argument>  
[Filters] <argument> ..... <argument>

Setting Syntax:

Setting or query

Type:

FILTERS

EVENT

Type:  
Query

Query Syntax:  
Event?

Query Response:  
EVENT <numeric>

Discussion:

The EVENT? query has the same action as the ERROR? query.



FPSET (FRONT PANEL SETTINGS)

FILTERS

For the setting command, multiple arguments separated by commas are allowed. The arguments are processed from left to right, that is the last argument prevails.

The FILTERS heading may be omitted for all arguments except OFF unless multiple arguments are used. If the FILTERS heading is omitted, the arguments ON or OFF may be optionally used. If not used, ON is assumed.

BP, LP, and WTG are all mutually exclusive.

The FILTERS? query returns a list of the filters that are enabled.

The INIT setting is FLAT.

**Type:** Operational  
**Setting Syntax:** FPset  
**Discussion:** The FPSET command sets the AA 5001 to the front panel settings even though it is under remote control. This is useful for allowing manually set input level and distortion ranges, as these are otherwise autoranged when in the remote state. Any other setting command made subsequently will defeat FPset.

FPSET (FRONT PANEL SETTINGS)



FUNCTION

FUNCTION

Discussion: DBM selects input level measurement in decibels relative to 0.775 volts.

IMDDB selects intermodulation distortion measurements in decibels.

IMDPCT selects intermodulation distortion measurements in percent.

THDDB selects total harmonic distortion measurements in decibels.

THDPCT selects total harmonic distortion measurements in percent.

VOLTS selects level measurement in rms volts.

The use of the FUNCTION header is optional.

NOTE

DB RATIO is not programmable. References other than 0.775 volts (DBM), if needed, should be calculated by the controller.

The FUNCTION? query returns the type of measurement selected. The FUNCTION header is not returned.

The INIT setting is VOLTS.

Type:

Setting or Query

Setting Syntax:

[Function] <argument>

Arguments:

- DBm
- IMDDB
- IMDPct
- THDDB
- THDPct
- Volts

Examples:

- Func IMDPct
- Func THDDB
- THDPct
- Volts

Query Syntax:

Function?

Query Response:

- DBM:
- DBR:
- IMDDB:
- IMDPCT:
- THDDB:
- THDPCT:
- VOLTS:





HELP

Type:  
Query

Query Syntax:  
HELP?

Query Response:  
HELP AVE.AVG.BP.COUNTS,DBM.DUS,ERRMSG,  
ERR.EVENT,EXT.FILT,FLAT.FPSET,FUNC,HELP,  
HP.ID,IMDDB,IMDPCT,INIT.LP.OPC,OVER.POINTS,  
OPK.RESP,RMS.RQS.SEND,SET,TEST,THDDB,  
THDPCT,TOL.VOLTS,WTG;

Discussion:  
The HELP? query returns a list of all valid command headers.

IDENTIFY

Type:  
Query

Query Syntax:  
IDENTIFY?

Query Response:  
ID TEK/AA5001,V81.1,Fx,y:(standard instrument only)  
ID TEK/AA5001,V81.1,Fx,y:"OPTION 2":(Option 02 only)

Discussion:  
The IDENTIFY? query returns the above response where:  
TEK/AA5001—identifies the instrument type.  
V81.1—identifies the version of Tektronix Codes and Format Standard to which the instrument conforms.  
Fx,y—identifies the firmware version of the instrument, where x,y is a decimal number.  
"OPTION 02"—identifies options if any.

HELP

IDENTIFY



### OPC (OPERATION COMPLETE SERVICE REQUEST)

Type: Setting or Query

Setting Syntax: OPC [ON]

OPC [ON]  
OPC OFF

Query Syntax: OPC?

Query Response: OPC ON; or OPC OFF

Discussion:

The OPC command controls the asserting of SRQ when a measurement is completed. This command allows a controller to start a measurement, and then process some other task while waiting for an SRQ to inform it that measurement data is ready.

When OPC is ON and a measurement completes, SRQ is asserted and remains asserted until the status is read via a serial poll or until cleared by RQS OFF or a Device Clear. Operation Complete is indicated by a Status Byte of 66 or 82 and an ERROR query response of ERR 402.

Refer to STATUS AND ERROR REPORTING in this section.

The power-up and INIT setting is OPC OFF.

OPC (OPERATION COMPLETE SERVICE REQUEST)

### INIT (INITIAL SETTINGS)

Type: Operational

Setting Syntax: INIT

INIT

Discussion:

The INIT command performs a power-on initialization of the instrument's settings. The initialization settings for the AA 5001 are:

- VOLTS
- RMS
- FLAT
- DUS ON
- POINTS 3
- TOLERANCE 2.0
- COUNTS 2.0
- OPC OFF
- OVER OFF
- RQS ON

The INIT command does not generate a power-on SRQ nor does it put the instrument in LOCAL mode as power-on initialization does.

INIT (INITIAL SETTINGS)



OVER (OVERRANGE SERVICE REQUEST)

Type: Setting or Query

Setting Syntax: Over [ON]  
Over OFF

Query Syntax: Over?

Query Response: OVER ON; or OVER OFF;

Discussion: The OVER command controls the asserting of SRQ for display overrange, insufficient level, excessive input level, and unsettled conditions.

These conditions are checked only when a measurement is attempted (see SEND command).

Refer to STATUS AND ERROR REPORTING in this section.

The power-up and INIT setting is OVER OFF.

OVER (OVERRANGE SERVICE REQUEST)

POINTS

POINTS

Type: Setting or Query

Setting or Query

Setting Syntax: Points <numeric>

Arguments: Any Floating Point Value from 2 to 6

Query Syntax: Points?

Query Response: POINTS <numeric>;

Discussion: The POINTS command sets the number of sample points, 2 through 6, that must be within the settling algorithm's tolerance window for settling to occur.

The numeric argument in the setting is rounded to the nearest integer. Refer to SETTLING ALGORITHM in this section.

The power-up and INIT setting is POINTS 3.

The POINTS? query returns the POINTS setting.



### RQS (REQUEST FOR SERVICE)

Type: Setting or query

Setting Syntax: RQS [ON]

RQS OFF

Query Syntax: RQS?

Query Response: RQS ON or OFF

Discussion:

The RQS command is a global control for assertion of SRQ by the AA 5001.

When RQS is OFF the AA5001 will not assert SRQ under any circumstance. When RQS is ON the AA5001 is allowed to assert SRQ under appropriate circumstances: i.e., errors, operation complete, etc.

The ERROR? query can be used while RQS is OFF to see if any SRQ type conditions have occurred.

SRQ will be asserted for any previously unreported SRQ event when RQS is turned ON after being OFF.

The power-up INIT setting is RQS ON.

### RQS (REQUEST FOR SERVICE)

### RESPONSE

Type:

Setting or query

Setting Syntax: [Response] <argument>

[Response] <argument>

Arguments:

Average (standard instrument only)  
AVG (standard instrument only)  
RMS  
Opk (Option 02 only)

Examples:

RESP AVE  
RESP RMS  
RMS

Query Syntax:

Response?

Query Response:

RESP AVG: or RESP RMS: (standard instrument only).

RESP QPK: or RESP RMS: (Option 02 only).

Discussion:

The RESPONSE command sets the AA 5001 for average (quasi-peak for Option 02) or rms response.

The RESPONSE query returns the RESPONSE setting.

The RESPONSE header is optional.

The power-up INIT setting is RESPONSE RMS.

### RESPONSE





SEND

Type: Output

Syntax:

SEND

Discussion:

The SEND command returns a measurement. Overrange is 1E-99. New measurements are available as the display reading may be returned only once.

If the DUS is OFF, the most recent display update is returned.

If DUS is ON, the measurement must be settled before it is returned. If settling does not occur within six (6) seconds, an average of the last two (2) seconds (6 display updates) is returned.

If the OVER is ON, an unsettled SRQ is generated.

Refer to SETTLING ALGORITHM, DUS, OVER, and TALKED WITH NOTHING TO SAY RESPONSE in this section.

SETTINGS

SEND

Type: Query

Query Syntax:

SETTINGS?

Query Response:

<string>

Example:

VOLTS:RESP RMS:FILT FLAT:DUS ON:POINTS  
3:TOL 1.0:COUNTS 1.0:OPC OFF:OVER OFF:RQS ON:

Discussion:

The SETTINGS? query returns the current settings of the instrument.

The SETTINGS? query response may then be used at a later time to reset the instrument back to those settings.

SETTINGS



TEST (ROM TEST)

TOLERANCE

Type:  
Query

Setting Syntax:  
TEST?

Output Response:  
TEST <numeric>

Discussion:  
The TEST? query causes execution of the ROM test and returns 0 if the test passes, or 394 if the test fails.

Type:  
Setting or Query

Setting Syntax:  
Tolerance <numeric>

Arguments:  
Any Floating Point Value from 0 to 100

Examples:  
TOI 12  
TOI 0.1E+2  
TOI 1.5

Query Syntax:  
Tolerance?

Query Response:  
TOL <numeric>

Discussion:  
The TOLERANCE command sets the tolerance window in percent of the reading for the setting algorithm. Refer to SETTLING ALGORITHM in this section.

The TOLERANCE? query returns the TOLERANCE setting.

The power-up INIT setting is TOLERANCE 2.0.

SETTLING ALGORITHM

This Algorithm delays a measurement from being sent until settling has occurred. The Settling Algorithm is enabled by using the DUS ON command. A settled AA 5001 measurement is obtained by using the SEND command to return a measurement with the Settling Algorithm previously enabled.

TEST (ROM TEST)

TOLERANCE



### Setting Algorithm

This Algorithm delays a measurement from being sent until settling has occurred. The Settling Algorithm is enabled by using the DUS ON command. A settled AA 5001 measurement is obtained by using the SEND command to return a measurement with the Settling Algorithm previously enabled.

The AA 5001 is considered settled when a series of measurement points (display updates) are within a specified tolerance of each other. The tolerance window is plus or minus the sum of the values set by the TOLERANCE command (in percent of reading from 0 to 100) and the COUNTS command (in display counts from 0 to 2000). The POINTS command sets the number of measurement points (from 2 to 6) that must be within the tolerance window for settling to occur. In general, specifying as wide of a tolerance window and as few points as the accuracy of the measurement needed allows, will cause the instrument to return a valid measurement with a minimum of delay. The default settings will provide good results under most test conditions.

The defaults are:  
POINTS 3  
TOLERANCE 2  
COUNTS 2

When enabled, the SETTLING ALGORITHM is continually collecting measurement points and keeping track of

### Remote Local Exceptions

If the LEVEL, THD-N, IMD, RESPONSE and any of the filter buttons are pressed, the AA 5001 returns to local from remote operation.

If settling does not occur within approximately six seconds after the SEND command is received, the AA 5001 returns the average of it's last six (6) measurement points (approximately 2 seconds, in duration). This averaging lowers usable measurements on signals containing low frequencies or noise. Additionally, if the OVER is ON, an unsettled SRQ is generated, alerting the controller that averaging has occurred.

time settling occurs.

the settling status. The algorithm is initialized at the time enabled (anytime DUS ON is received), or when any set measurement points are dumped. At least two (2) points be taken after receiving the SEND command before settling status can occur. The remaining points, if needed, may have been collected before the SEND command was received; the algorithm was enabled with sufficient time to collect these points. This ensures that the algorithm includes effects of any system changes that were made near the time the SEND command is received, but returns a measurement sooner if the AA 5001 remains settled. The measurement returned is the most recent measurement point taken at the time settling occurs.



# MESSAGES AND COMMUNICATION PROTOCOL

## Command Separator

A message consists of one command or a series of commands, followed by a message terminator. Messages consisting of multiple commands must have the commands separated by semicolons. A semicolon at the end of a message is optional. For example, each line below is a message.

```
INIT
TEST:INIT:RQS ON;DUS OFF;ID?;SET? -
TEST:
```

## Message Terminator

Messages may be terminated with EOI or the ASCII line feed (LF) character. Some controllers assert EOI concurrently with the last data byte. Others use only the LF character as a terminator. With EOI ONLY selected as the terminator, the instrument interprets a data byte received with EOI asserted at the end of the input message; it also asserts EOI concurrently with the last byte of the output message. With the LF/EOI setting, the instrument interprets the LF character without EOI asserted (or any data byte received with EOI asserted) as the end of an input message. The AA 5001 transmits carriage return (CR) followed by line feed (the LF with EOI asserted) to terminate output messages. Refer service personnel to the Maintenance section of the manual for information on setting the message terminator. TM 5000 instruments are shipped with EOI ONLY selected.

## Formatting A Message

Commands sent to the AA 5001 must have the proper format (syntax) to be understood. This format is flexible and many variations are acceptable. The following describes this format and the acceptable variations.

All commands must be encoded in upper and lower case ASCII. All data output is in upper case. See Fig. 3-2.

As previously discussed, a command consists of a header followed, if necessary, by arguments. A command with arguments must have a header delimiter which is the space character SP between the header and the argument. The space character <sup>sp</sup>, carriage return <sup>CR</sup>, and line feed <sup>LF</sup> are shown as subscripts in the following examples.

RQSp ON

If extra formatting characters SP, CR, and LF (the LF cannot be used for format in the LF/EOI terminator mode)

## Number Formats

The instrument accepts the following kinds of numbers for any of the numeric arguments.

- Signed or unsigned integers (including +0 and -0). Unsigned integers are interpreted as positive. Examples: +1, 2, -1, -10.
- Signed or unsigned decimal numbers. Unsigned decimal numbers are interpreted as positive. Examples: -3.2, +5.0, .2.

In the last example, the space is treated as a format character because it follows the comma (the argument delimiter).

## NOTE

```
2.3
2sp 3
2sp 3
```

Multiple arguments are separated by a comma; however, the instrument will also accept a space or spaces as a delimiter.

```
EV?
EV?
Event?
Event A?
```

In the command list, some letters are capitalized and others are lower case. The capitalized letters are the minimum necessary for command recognition. However, if additional letters are added they must be the same as shown in the header. For documentation of programs, the user may add alpha characters to the full header. Alpha characters may also be added to the query header, provided the question mark is at the end.

```
RQSp ON;CR LF
DUSp OFF
```

In general, these formatting characters are ignored after any delimiter and the beginning and end of a message.

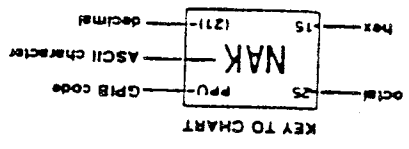
```
Example 1: RQSp ON;
Example 2: RQSp SP ON;
Example 3: RQSp CR LF SP ON;
```

are added between the header delimiter and the argument, they are ignored by the instrument.





Fig. 3-2. ASCII and IEEE 488 (GPIB) code chart.



ADDRESSING COMMANDS		UNIVERSAL COMMANDS		LISTEN ADDRESSES		TALK ADDRESSES		SECONDARY ADDRESSES OR COMMANDS	
87	0	0	0	0	0	0	0	0	0
86	0	0	0	0	0	0	0	0	0
85	0	0	0	0	0	0	0	0	0
84	83	82	81	CONTROL		NUMBERS		UPPER CASE	
0	0	0	0	20	40	60	80	100	120
0	0	0	0	NUL	SP	0	@	P	140
1	0	0	0	SOH	DC1	1	A	Q	160
2	0	0	0	STX	DC2	2	B	R	180
3	0	0	1	ETX	DC3	3	C	S	200
4	0	1	0	EOT	DCL	4	D	T	220
5	0	1	0	ENQ	PPU	5	E	U	240
6	0	1	0	ACK	SYN	6	F	V	260
7	0	1	1	BEL	ETB	7	G	W	280
8	0	0	0	BS	CAN	8	H	X	300
9	0	0	1	HT	EM	9	I	Y	320
10	0	0	0	LF	SUB	10	J	Z	340
11	0	0	1	VT	ESC	11	K	[	360
12	0	1	0	FF	FS	12	L	\	380
13	0	1	0	GS	GS	13	M	]	400
14	0	1	0	RS	RS	14	N	^	420
15	0	1	1	SI	US	15	O	_	440
16	1	1	1	SO	SO	16	P	~	460
17	1	1	1	SI	US	17	Q	DEL	480
18	1	1	1	RU	RU	18	R	DEL	500

ASCII & IEEE 488 (GPB) CODE CHART



When buffer space is available, the instrument accepts a second message before processing the first. However, additional messages are held off with NRF D until the first message is processed completely.

After the instrument executes a query-output command the response holds the output buffer until the instrument becomes a talker. If a new message is received before all of the output from the previous message is read the output buffer is cleared before executing the new message. This prevents the controller from getting unwanted data from old messages.

One other situation may cause the instrument to delete output. The execution of a long message might fill both the input and output buffers. When this occurs, the instrument cannot finish executing the message because it is waiting for the controller to read the data it has generated. But the controller cannot read the data because it is waiting to finish sending its message. Because the instruments input buffer is full and the remainder of the controllers message is held off by NRF D, the system is hung up. The controller and instrument are waiting for each other. When the instrument detects this condition, it generates an error, asserts SRQ and deletes the data in the output buffer. This allows the controller to transmit the rest of the message and informs the controller that the message was executed and the output was deleted.

### Instrument Response to IEEE-488 Interface Messages

Interface messages and their effects on the instruments interface functions are defined in IEEE Standard 488-1978. Abbreviations from the standard are used in this discussion, which describe the effects of interface messages on instrument operation.

Bus interface control messages are sent as low level commands through the use of WBYTE controller commands. For the following commands A = 32 plus the instrument address and B = 64 plus the instrument address.

- WBYTE @ A: Listen
- WBYTE @ B: Unlisten
- WBYTE @ 63: Talk
- WBYTE @ 95: Unlisten
- WBYTE @ 20: Device clear (DCL)
- WBYTE @ 63, 95: Unlisten
- WBYTE @ 20: Selective device clear (SDC)
- WBYTE @ A, 4: Go to local (GTL)
- WBYTE @ A, 17, 63: Remote with lockout
- WBYTE @ A, 17: Local lockout of all instruments
- WBYTE @ A, 8: Group execute trigger (GET)

• Floating point numbers expressed in scientific notation. Examples:  $-1.0E-2$ ,  $1.47E1$ ,  $1.E-2$ ,  $0.01E+0$ .

### Rounding of Numeric Arguments

The instrument rounds numeric arguments to the nearest unit of resolution and then checks for out-of-range conditions.

### Message Protocol

As the instrument receives a message it is stored in the input buffer, processed, and executed. Processing a message consists of decoding commands, detecting delimiters and checking syntax. For setting commands, the instrument stores the indicated changes in the pending settings buffer. If an error is detected during processing, the instrument asserts SRQ, ignores the remainder of the message, and resets the pending settings buffer. Resetting the pending settings buffer avoids undesirable states which could occur if some setting commands are executed while others in the same message are not.

Executing a message consists of performing the actions specified by its command(s). For setting commands, this involves updating the instrument settings and recording these updates in the current settings buffer. The setting commands are executed in groups—that is, a series of setting commands is processed and recorded in the pending settings buffer before execution takes place. This allows the user to specify a new instrument state without considering a particular sequence is valid. Execution of the settings occurs when the instrument processes the message terminator, a query-output command, or an operational command.

When the instrument processes a query-output command and any preceding setting commands are executed to update the state of the instrument. The query-output command is then executed by retrieving the appropriate data and putting it in the output buffer. Then, processing and execution continue for the remainder of the message. When the instrument is made a talker the data is sent to the controller.

When the instrument processes an operational command, it executes any preceding setting commands before executing the operational command.

### Multiple Messages

A single message may be long enough to fill the input buffer. If so, a portion of the message is processed before the instrument accepts additional input. During command processing the instrument holds off additional data (by asserting NRF D) until space is available in the buffer.



These commands are for the TEKTRONIX 4041 and 4050-Series controllers and representative for other controllers.

**UNT—Unlisten**  
**UNT—Untalk**

When the AA 5001 receives the UNT command the listener function goes to the idle state (unaddressed). In the idle state, the AA 5001 does not accept instrument commands from the GPIB.

The talker function goes to the idle state when the AA 5001 receives the UNT command. In this state, the AA 5001 cannot output data via the GPIB.

The ADPS light is off when both the talker and listener functions are idle. The light is on if the instrument is either talk or listen addressed.

**IFC—Interface Clear**

This unitline message has the same affect as both the UNT and UNL messages. The front panel ADPS light is off.

**DCL—Device Clear**

The Device Clear message reinitializes communication between the instrument and controller. In response to DCL, the instrument clears any input and output messages and any unexpected settings in the pending settings buffer. Also cleared are any errors or events waiting to be reported, except the power-on events. When DCL is received by the AA 5001 an SRQ is unasserted if the SRQ line was asserted for any reason other than power-on.

**SDC—Selected Device Clear**

This message performs the same function as DCL; however, only instruments that are listen addressed respond.

**GET—Group Execute Trigger**

The AA 5001 recognizes the GET message. Upon receipt the AA 5001 issues an error.

**SPE—Serial Poll Enable**  
**SPD—Serial Poll Disable**

The SPE message enables the AA 5001 to output serial poll status bytes when it is talk addressed. The SPD message switches the AA 5001 to sending data from the output buffer.

**MLA—My Listen Address**  
**MTA—My Talk Address**

The primary listen and talk addresses are established to the AA 5001 GPIB address (internally set). When the AA 5001 is addressed to talk or listen, the front panel ADPS indicator illuminates.

**LLO—Local Lockout**

In response to LLO, the AA 5001 goes to a lockout state—from LOCS to LWLS or from REMS to RWLS.

**REN—Remote Enable**

If REN is true, the instrument goes to a remote state (from LOCS to REMS or from LWLS to RWLS) when its listen address is received. When REN is false a transition from any state to LOCS. The AA 5001 stays in LOCS as long as REN is false.

A REN transition may occur after message processing has begun. In this case execution of the message being processed is not affected.

**GTL—Go To Local**

Only instruments that are listen addressed respond to GTL. Remote-to-local transitions caused by GTL do not affect the execution of the message being processed when GTL is received.

**Talked With Nothing to Say Response**

The AA 5001 can be made a talker without having received a message that specifies the output. If the AA 5001 is talk addressed (receives MTA) without being specifically told what to say, it returns a measurement as if the SEND command was received. Refer to the SEND command in this section.

**Remote-Local Operation**

The preceding discussion described the state transitions caused by GTL and REN. The LEVEL, THD+N, IMD RE-SPONSE or FILTERS pushbuttons cause a transition from REMS to LOCS by asserting a message called return-to-local (RTI). This transition may occur during message execution. In contrast to GTL and REN transitions, a transition initiated by RTI does affect message execution. The instrument generates an error if there are any unexecuted setting or operational commands.

The instrument maintains a record of its settings in the current settings buffer. New settings from the front panel or



Both the input range and distortion range are forced to auto-range except when the "Fpsr" command is used (see Fpsr).

**Remote With Lockout State (RWLS)**

Instrument operation is identical to REMS operation except the  $\bar{r}$  message is ignored.

**STATUS AND ERROR REPORTING**

Through the Service Request function (defined in the IEEE-488 Standard), the instrument alerts the controller that it needs service. This service request is also a means of indicating that an event (a change in status or an error) has occurred. To service a request the controller performs a Serial Poll. In response the instrument returns a Status Byte (STB) which indicates if it requested service. The STB also provides a limited amount of information about the request. The format of information encoded in the STB is given in Fig. 3-3. When data bit 8 is set, the STB conveys Device Status information indicated by bits 1 through 4.

The controller update these settings. In addition, the front panel is updated to reflect setting changes due to commands. The REMOTE indicator is illuminated when the instrument is in REMS or RWLS.

**Local State (LOCS)**

In LOCS, instrument settings are controlled by the operator via front panel pushbuttons. When in LOCS, only bus commands that do not change instrument settings are executed (query-output commands). All other bus commands (setting and operational) generate an error as their functions are under front panel control.

**Local With Lockout State (LWLS)**

The instrument operates the same as in LOCS, except  $\bar{r}$  does not inhibit a transition to remote.

**Remote State (REMS)**

In this state, the instrument executes all instrument commands. For commands having front panel indicators, the front panel is updated when the commands are executed.

STATUS BYTE (Example)	DECIMAL WEIGHT	Normal Conditions:	Power-up	Operation complete	Display overrange	No events	Device Dependent Events:	Insufficient input level	Excessive input level	Unsettled	Abnormal Conditions:	Command errors	Execution errors	Internal errors
8	128	1	0	0	0	1	1	1	1	1	0	0	0	0
7	64	1	1	1	0	0	0	0	0	0	0	1	1	1
6	32	1	0	1	0	0	0	0	0	0	0	1	1	1
5	16	0	0	0	0	0	0	0	0	0	0	0	0	0
4	8	0	0	0	0	0	0	0	0	0	0	0	0	0
3	4	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Bit 5														
not asserted														
Bit 5														
asserted														
81	65	0	0	0	0	0	0	0	0	0	0	0	0	0
82	66	0	1	0	0	0	0	0	0	0	0	0	0	0
84	68	0	1	0	0	0	0	0	0	0	0	0	0	0
144	128	1	0	0	0	0	0	0	0	0	0	0	0	0
209	193	1	0	0	0	0	0	0	0	0	0	0	0	0
211	195	1	1	0	0	0	0	0	0	0	0	0	0	0
212	196	1	1	0	0	0	0	0	0	0	0	0	0	0
113	97	0	1	1	0	0	0	0	0	0	0	0	0	0
114	98	0	1	1	0	0	0	0	0	0	0	0	0	0
115	99	0	1	1	0	0	0	0	0	0	0	0	0	0

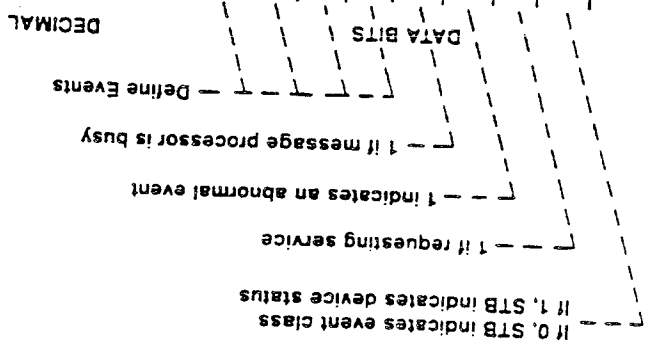


Fig. 3-3. Definition of status bytes.





As the STB conveys limited information about an event, the events are divided into classes; the Status Byte reports the class of events. The classes of events are listed as follows:

**COMMAND ERROR**

Indicates the instrument received a command which it cannot understand.

**EXECUTION ERROR**

Indicates that the instrument received a command that it cannot execute. This is caused by arguments out of range or settings that conflict.

**INTERNAL ERROR**

Indicates that the instrument has detected a hardware condition or firmware problem that prevents operation.

**SYSTEM EVENTS**

Events that are common instruments in a system (e.g., Power on, User Request, etc.).

**INTERNAL WARNINGS**

The instrument has detected a problem. The instrument remains operational but it is recommended that the problem should be corrected. Device dependent events.

**DEVICE STATUS**

The instrument can provide additional information about many of the events. After determining that the instrument requested service (by examining the STB) the controller may request additional information by sending an event query (EVENT). In response, the instrument returns a code which defines the event. These codes are described in Table 3-1.



To report more than one event, the instrument continues to assert SRQ until all events are reported. Each event is cleared when reported via Serial Poll. The Device Clear (DCL) interface message clears all events except Power On. Some commands control reporting of certain individual events and disable all service requests. For example, the Request for Service command (RQS) controls the reporting of events with SRQ. The Operation Complete Service Request for Service command (RQS) controls the reporting of events with SRQ. The Operation Complete Service Request for Service command (RQS) controls the reporting of events with SRQ. The Operation Complete Service Request for Service command (RQS) controls the reporting of events with SRQ. The Operation Complete Service Request for Service command (RQS) controls the reporting of events with SRQ.

RQS OFF inhibits all SRQs. In this mode the EVENT? query allows the controller to find out about events without performing a Serial Poll. With RQS OFF, the controller may send the EVENT? query at any time and the instrument re-quest (OPC) asserts SRQ where a valid reading is available. The Overrange Service Request (OVER) command asserts SRQ for overrange, increasing range or decreasing range conditions.

If the message processor is busy, the instrument returns the higher decimal number.

Event	Bus response to ERR?	Response to serial poll
Abnormal Conditions		
Command Errors	101 102 103 104 106 107	97 or 113 97 or 113 97 or 113 97 or 113 97 or 113 97 or 113
Execution Errors	201 202 203 205 206	98 or 114 98 or 114 98 or 114 98 or 114 98 or 114
Internal Errors	301 302 303	99 or 115 99 or 115 99 or 115
Normal Conditions		
System Events	401 402	65 or 81 66 or 82
Power on		
Operation complete		
Execution Warning		
Display overrange		
Device Dependent Events	601	68 or 84
Insufficient input level	701	193 or 209
Excessive input level	703	195 or 211
Unsettled	704	196 or 212
No Errors or Events	0	0 or 16
With data not ready	128 or 144	
With data ready	132 or 148	

Table 3-1  
ERROR QUERY AND STATUS INFORMATION



Turns an event waiting to be reported. The controller can clear all events by sending the EVENT? query until a zero (0) code is returned, or clear all events except power-on through the DCL interface message.

With ROS OFF the controller may perform a Serial Poll, but the Status Byte only contains Device Dependent Status information. With ROS ON, the STB contains the class of the event and a subsequent EVENT? query returns additional information about the previous event reported in the STB.

**Power Up (Initial) Conditions**

During power up, the AA 5001 microprocessor performs a diagnostic routine (self test) to check the functionality of the ROM and RAM. If no error is found, the instrument enters the Local State (LOCS) with the default settings as listed in Table 3-2. The SRQ line on the GPIB is asserted. If an internal error is found, an error code is displayed in the front-panel readout. See Table 6-3 in the Maintenance Section for front panel error displays.

**Table 3-2  
POWER UP SETTINGS**

Header	Argument
COUNTS	2.0
DUS	ON
FILT	ON
FUNC	FLAT
OPC	VOLTS
POINTS	OFF
RESP	3
ROS	RMS
TOL	2.0
OVER	OFF

The instrument goes to the front panel settings and the following at power-up:

**The POLL Statement and Clearing SRQ**

The POLL statement causes the BASIC interpreter in the 4050 series controllers to serially poll each peripheral device on the General Purpose Interface Bus (GPIB) to determine if the device requesting service. When the device is found, the device sends its status byte to the BASIC interpreter over the GPIB.

The POLL statement is normally executed in response to a service request from a peripheral device on the GPIB. Two

This statement shows a method of clearing the service request. Two numeric variables A and B are specified. Following the variables is the semicolon delimiter and the instrument address or the alpha character defined as the instruments primary address. After the device requesting service is found the devices position in the list is assigned to the first variable. The status word from this device is assigned to the second variable.

**POLL A,B:22**

The AA 5001 asserts SRQ during power up or power down. The power up SRQ must be cleared before continuing.

numeric variables are specified as parameters in the POLL statement followed by a series of I/O addresses. The BASIC interpreter polls the first I/O address in the list, the second I/O address, the third, and so on, until the device requesting service is found. Program execution is halted, if the I/O address of the device requesting service is not in the list.

**Information Available**

Additional assistance in developing specific application oriented software is available in the following Tektronix manuals.

- (1) 070-3985-00—GPIB Programming Guide. This manual is specifically written for applications of this instrument in IEEE-488 systems. It contains programming instructions, tips and some specific examples programs.
- (2) 070-3917-00—4041 System Controller Programmer's Reference manual.
- (3) 070-2270-00—4051 GPIB Hardware Support Manual. This manual gives an in-depth discussion of IEEE-488 bus operation, explanations of bus timing details and early bus interface circuitry.
- (4) 070-2058-01—Programming in BASIC.
- (5) 070-2059-01—Graphic Programming in BASIC.
- (6) 070-2380-01—4907 File Manager Operators manual.
- (7) 070-2128-00—4924 Users manual.
- (8) 070-1940-01—4050 Series Graphic System Operators manual.
- (9) 070-2056-01—4050 Series Graphic System Reference manual.
- (10) 070-3918-00—4041 Operators manual.
- (11) 061-2546-00—4041 Programming Reference manual.



# PROGRAMMING EXAMPLES

```

100 ***** TALKER/LISTENER PROGRAM FOR 4052A / AA 5001 *****
110 *****
120 *****
130 *****
140 Oct 4, 1983
150
160 PURPOSE:
170 Supports operator interaction with the AA 5001 over the GPIB.
180 The operator may enter AA 5001 commands and observe the
190 results. Service requests, such as for an incorrect command,
200 are handled.
210
220 REQUIRED EQUIPMENT:
230 4052A Controller
240 AA 5001 Programmable Distortion Analyzer.
250
260 VARIABLES USED:
270
280 Aa_pri_addr -- AA 5001 primary address. Assigned value of 28.
290 Change if instrument set to other address.
300
310 Spoll_stat -- Status returned by serial poll from first
320 instrument requesting service.
330
340 Addr_list_index -- Address list index returned by serial poll.
350
360 Addr_list -- Array of addresses found by CONFIG routine.
370
380 Config_code -- Flag returned by config routine.
390
400 Aa_commands -- Commands entered by the operator and directed
410 to the AA 5001.
420
430 Aa_responses -- Response from the AA 5001 to Sg_commands
440 (null if no output command contained in Aa_commands).
450
460 ROUTINE CALLED:
470 Serial poll subroutine handles instrument service requests
480 from all instruments on the bus.
490
500 POSSIBLE ERRORS:
510 AA 5001 primary address is set different than the number
520 assigned to Aa_pri_addr.
530
540 INIT
550 DIM Aa_responses(300),Aa_commands(100),Addr_list(15)
560 Aa_pri_addr=28
570
580 CALL "config",Config_code,Addr_list
590 IF Config_code THEN
600 PRINT "Configuration routine failed due to problem on GPIB."
610 STOP
620 END IF
630
640 ON SRO THEN 790
650
660 PRINT "AA 5001 TALKER/LISTENER PROGRAM"
670
680 PRINT "Enter command message: ?"
690 INPUT Aa_command
700 PRINT @Aa_pri_addr:Aa_commands
710 INPUT @Aa_pri_addr:Aa_responses
720 PRINT Aa_responses

```

Fig. 3-4. AA 5001 Talker Listener Program (4052A).





Fig. 3-5. AA 5001 Talker Listener Program (4041).

```

100 ***** TALKER/LISTENER PROGRAM FOR 4041 / AA 5001 *****
110 *****
120 *****
130 *****
140 *****
150 *****
160 *****
170 *****
180 *****
190 *****
200 *****
210 *****
220 *****
230 *****
240 *****
250 *****
260 *****
270 *****
280 *****
290 *****
300 *****
310 *****
320 *****
330 *****
340 *****
350 *****
360 *****
370 *****
380 *****
390 *****
400 *****
410 *****
420 *****
430 *****
440 *****
450 *****
460 *****
470 *****
480 *****
490 *****
500 *****

```

500 bus selected by the AA 5001 stream spec.  
 490 Pollus Handles request for service from any instrument on the  
 480 ROUTINE CALLED:  
 470  
 460 100: Assigned to AA 5001 stream spec.  
 450 LOGICAL UNIT USED:  
 440  
 430 command contained in commands).  
 420 Response -- Response of the AA 5001 to commands (null if no output  
 410 Commands -- Commands entered by the operator and directed to the AA 5001.  
 400 Spolladr -- Address of first instrument found requesting service.  
 390 Spollsta -- Status returned by first instrument found requesting service.  
 380 Spollsta -- Stream specification for AA 5001.  
 370  
 360 Change if instrument is connected to GPIB instead of GPIBO.  
 350  
 340  
 330  
 320  
 310  
 300  
 290  
 280  
 270  
 260  
 250  
 240  
 230  
 220  
 210  
 200  
 190  
 180  
 170  
 160  
 150  
 140  
 130  
 120  
 110  
 100

Fig. 3-4 (cont). AA 5001 Talker Listener Program (4052A).

```

730 GO TO 680
740 END
750
760
770 LOCAL Aa_reports
780 DIM Aa_reports(80)
790 POLL Addr_list_indx, Spoll_stat, Addr_list
800 IF Addr_list_indx=Spoll_stat THEN
810 PRINT @aa_prt_addr: "id?errmsg?"
820 INPUT @aa_prt_addr: Aa_reports
830 PRINT "ADDRESS="; Aa_reports
840 PRINT Aa_reports
850 END IF
860 RETURN

```

860 RETURN  
 850 END IF  
 840 PRINT Aa\_reports  
 830 PRINT "ADDRESS="; Aa\_reports  
 820 INPUT @aa\_prt\_addr: Aa\_reports  
 810 PRINT @aa\_prt\_addr: "id?errmsg?"  
 800 IF Addr\_list\_indx=Spoll\_stat THEN  
 790 POLL Addr\_list\_indx, Spoll\_stat, Addr\_list  
 780 DIM Aa\_reports(80)  
 770 LOCAL Aa\_reports  
 760  
 750  
 740 END  
 730 GO TO 680



Fig. 3-6. AA 5001 program example (4050A series).

```

100 *****
110 ***** TOTAL HARMONIC DISTORTION VERSUS FREQUENCY *****
120 *****
130 *****
140 For 4050A Series: July 22, 1983
150 Revised: September 28, 1983
160 Copyright (c) 1983 Tektronix, Inc. All rights reserved. This
170 software is provided on an "as is" basis without warranty of
180 any kind. It is not supported.
190 This program may be reproduced without prior permission, in
200 whole or in part, by the original purchaser. Copies must
210 include the above copyright and warranty notice.
220 PURPOSE:
230 Records the total harmonic distortion of a system to a leveled
240 input signal which is swept from 10 Hz-100 KHz in logarithmic
250 fashion. The total number of points is 21. The results are then
260 plotted on the 4050A Series screen.

```

Fig. 3-5 (cont). AA 5001 Talker Listener program (4041).

```

510 POSSIBLE ERRORS:
520 aa_pa or aa_port variables do not match the AA 5001 primary address or
530 port where AA 5001 is connected, respectively.
540 Dim responses to 300/commands to 100/aastrem$ to 20
550 aa_pa=28
560 aa_port=0
570 Aastrem$="SPB"&str$(aa_port)&"(pri="&str$(aa_pa)&"):
580 Select aastrem$
590 On sra then call polibus
600 Enable sra
610 Input prompt "Enter command message: ":commands
620 Print response:response
630 Goto tik_lisn
640 End i main
650 Sub polibus local reports
660 PURPOSE:
670 Handles spib service requests. Poles all primary addresses until
680 source of sra is found. If sra from instrument at AA 5001 primary
690 address, routine queries id and error message.
700 LOCAL VARIABLE:
710 Reports: id and event report from instrument at aa_pa if it has sra.
720 Dim reports to 80
730 Polibus reports to 80
740 Polibus local reports
750 Polibus local reports
760 Polibus local reports
770 Polibus local reports
780 Polibus local reports
790 Polibus local reports
800 Polibus local reports
810 Polibus local reports
820 Polibus local reports
830 Polibus local reports
840 Polibus local reports
850 Polibus local reports
860 Polibus local reports
870 Polibus local reports
880 Polibus local reports
890 Polibus local reports
900 Polibus local reports
910 Polibus local reports
920 Polibus local reports
930 Polibus local reports
940 Polibus local reports

```



```

300 REQUIRED EQUIPMENT:
310 AA 5001 Programmable Distortion Analyzer.
320 SG 5010 Programmable 160 KHz Oscillator.
330 4050A Series Controller
340
350 PROGRAM SEGMENT VARIABLES:
360 aaprim
370 SG 5010 primary address. Factory set to 28.
380 nsteps
390 number of frequency steps.
400 array of calculated frequencies.
410 thdaray
420 array of measured total harmonic distortion.
430 frestrt
440 sweep starting frequency.
450 toleran
460 tolerance for Delay Unit!! Settled algorithm.
470 counts
480 number of counts for IUS algorithm in AA 5001.
490 _points
500 number of readings to be within tolerance and
510 output amplitude of SG 5010.
520 OPERATING INSTRUCTIONS:
530 Connect output of SG 5010 to input of Device Under Test.
540 Connect output of DUT to input of AA 5001. Address of AA 5001
550 must be set to 28 and address of SG 5010 must be set to 25. If
560 variables aaprim ( AA 5001 primary address ) and sprim ( SG 501
570 primary address ) must be changed accordingly.
580 ERRORS:
590 AA 5001 and SG 5010 addresses must be set to 28 and 25
600 respectively on program assignments of variables aaprim
610 and sprim changed in program.
620 INSTRUMENT CONTROL:
630 Polls instruments on assigned addresses (AA 5001 and SG 5010).
640
650 *****
660 INIT
670 PAGE
680 aaprim=28
690 sprim=25
700 nsteps=21
710 DIM Frearay (Nsteps), Thdaray (Nsteps)
720 Frestrt=10
730 Frestop=100000
740 toleran=0.1
750 Counts=1
760 _points=6
770 Amplitt=1
780 Ttitles="THD VERSUS FREQUENCY"
790 Xtitles="Frequency in Hertz"
800 Ytitles="THD in Percent"
810 ON SRQ THEN 1950
820
830
840
850 CALL Sweeplos(Frestrt,Frestop,Nsteps, Frearay)
860
870
880 Initialize Instruments
890 MWRITE @aaprim+32,Sprim+32:73,78,73,-84
900 MWRITE @95,43:
910 Lock out the AA 5001 and the SG 5010 front panels.
920 MWRITE g17:
930
940
950
960
970
980
990
1000
1010
1020
1030
1040
1050
1060
1070
1080
1090
1100
1110
1120
1130
1140
1150
1160
1170
1180
1190
1200
1210
1220
1230
1240
1250
1260
1270
1280
1290
1300
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1600
1610
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1630
1640
1650
1660
1670
1680
1690
1700
1710
1720
1730
1740
1750
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1770
1780
1790
1800
1810
1820
1830
1840
1850
1860
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000

```

Fig. 3-6 (cont). AA 5001 program example (4050A series).



Fig. 3-6 (cont). AA 5001 program example (4050A series).

```

930 PRINT GASP: "FUNG THDP: FILT OFF: RESP RMS"
940 I Set up AA 5001 to delay sending a reading until settled.
950 I Set tolerance, number of counts, and number of points.
960 PRINT GASP: "DUS ON: TOL ? / tolerance; / COUNTS ? / counts"
970 PRINT GASP: "POINTS ? / points"
980 I Set up SG 5010 for an RMS balanced output, out on display freq.
990 PRINT GASP: "VRMS ? / Amp; / ? / Hz; / ON: / DISP FREQ"
1000 FOR Count=1 TO Nsteps
1010 PRINT GASP: "FREQ ? / Freq: (Count)"
1020 PRINT GASP: "SEND"
1030 INPUT GASP: "Thd: (Count)"
1040 NEXT Count
1050 CALL Pltloop(Nsteps, Freq:ay, Thd:ay, T:itles, Y:titles)
1060 I Unlock all instruments on the bus.
1070 CALL "RENDF"
1080 CALL "RENON"
1090 OFF SRD
1100 END
1110 SUB Sweepof(Freqstr, Freqstop, Nsteps, Freq:ay)
1120 _steps=Nsteps-1
1130 _stepsize=(LGT(Freqstop)-LGT(Freqstr))/_steps
1140 Index=0
1150 FOR Count=LGT(Freqstr) TO LGT(Freqstop) STEP _stepsize
1160 Index=Index+1
1170 Freq:ay(Index)=10*Count
1180 NEXT Count
1190 END SUB
1200 SUB Pltloop(Nsteps, Freq:ay, Thd:ay, T:itles, Y:titles)
1210 PAGE
1220 WINDOW 0,130,0,100
1230 VIEWPORT 0,130,0,100
1240 PRINT "I"
1250 PRINT "J"
1260 FOR I=1 TO LEN(Y:titles)
1270 S=SEG(Y:titles,I,1)
1280 PRINT USING 1290:SS
1290 IMAGE A/
1300 NEXT I
1310 MOVE 0,4
1320 PRINT "I"
1330 VIEWPORT 20,120,20,85
1340 FOR Index=1 TO Nsteps
1350 Low=Thd:ay(I)
1360 IF Thd:ay(Index)<Low THEN
1370 Low=Thd:ay(Index)
1380 END IF
1390 NEXT Index
1400 High=Thd:ay(I)
1410 FOR Index=1 TO Nsteps
1420 IF Thd:ay(Index)>High THEN
1430 High=Thd:ay(Index)
1440 END IF
1450 NEXT Index
1460 High=INT((10*High+1)/10)
1470 Low=INT((10*Low-1)/10)
1480 IF Low=>0 THEN
1490 Low=0
1500 END IF
1510 Diff=High-Low
1520 WINDOW 10,50,Low,High
1530 MOVE 10,High
1540 DRAW 10,Low

```





Fig. 3-6 (cont). AA 5001 program example (4050A series).

```

1550 DRAM 50,Low
1560 DRAM 50,His
1570 DRAM 10,His
1580 FOR P=1 TO 4
1590 FOR Q=2 TO 10
1600 T=10*LGTR(Q*10^P)
1610 MOVE T,Low
1620 FOR TIC=Low TO HIS STEP 0.1*DIFF
1630 REMOVE 0,-0.01*DIFF
1640 RDRAM 0,0.02*DIFF
1650 MOVE T,TIC
1660 NEXT TIC
1670 NEXT Q
1680 MOVE P*10-0.75,Low-0.1*DIFF
1690 PRINT "10"
1700 REMOVE 0.7,0.05*DIFF
1710 PRINT P
1720 MOVE T,Low
1730 DRAM T,His
1740 NEXT P
1750 MOVE P*10-0.75,Low-0.1*DIFF
1760 PRINT "10"
1770 REMOVE 0.7,0.05*DIFF
1780 PRINT P
1790 FOR HOR=Low TO HIS STEP 0.1*DIFF
1800 MOVE 4,Hor-0.01*DIFF
1810 IF HOR=0 THEN 1840
1820 PRINT USING "2D.3D2A":HOR,"%
1830 GO TO 1850
1840 PRINT USING "2ADD":HOR,"%
1850 MOVE 10,Hor
1860 DRAM 50,Hor
1870 NEXT HOR
1880 MOVE 10*LGTR(FREARAY(1)),THDARAY(1)
1890 FOR COUNT=2 TO NSTEPS
1900 DRAM 10*LGTR(FREARAY(COUNT)),THDARAY(COUNT)
1910 NEXT COUNT
1920 HOME
1930 END SUB
1940 I SRD Handler
1950 DIM ES(60)
1960 EFLAG=0
1970 POLL ADDR,StabYt,AppriM;SerrM
1980 GOSUB ADDR OF 2000,2040
1990 GO TO 2360
2000 PRINT GAPPriM:"ID?ERR?"
2010 INPUT GAPPriM:ES
2020 Addr=AppriM
2030 GO TO 2070
2040 PRINT GAPPriM:"ID?ERR?"
2050 INPUT GAPPriM:ES
2060 Addr=SerrM
2070 LPOS(ES,"ERR",1)
2080 Error=SEG(ES,L,10)
2090 Error=VAL(Error$)
2100 S=SEG(ES,B,6)
2110 IF S="AA5001" AND Error=601 THEN
EFLAG=1
2120 END IF
2130 END IF
2140 IF S="AA5001" AND Error=701 THEN
EFLAG=2
2150 END IF
2160 END IF
2170 IF S="AA5001" AND Error=703 THEN
EFLAG=3

```



Fig. 3-7. AA 5001 program example (4041).

```

100 *****
110 ***** TOTAL HARMONIC DISTORTION VERSUS FREQUENCY *****
120 *****
130 *****
140 For 4041: July 22, 1983      Revised: September 28, 1983
150
160 Copyright (c) 1983 Tektronix, Inc. All rights reserved. This
170 software is provided on an "as is" basis without warranty of
180 any kind. It is not supported.
190 This program may be reproduced without prior permission, in whole
200 or in part, by the original purchaser. Copies must include the
210 above copyright and warranty notice.
220
230 PURPOSE:
240 Records the total harmonic distortion of a system to a leveled
250 input signal which is swept from 10 Hz to 100 KHz in logarithmic
260 fashion. The total number of points is 21. The results are then
270 printed out on the 4041 printer.
280
290 REQUIRED EQUIPMENT:
300 AA 5001 Programmable Distortion Analyzer.
310 SG 5010 Programmable 160 KHz Oscillator.
320 4041 Controller (V2.0)
330
340 PROGRAM SEGMENT VARIABLES:
350 AA 5001 Primary address. Factory set to 28.
360 SG 5010 Primary address. Factory set to 25.
370 AA 5001 logical unit number.
380 SG 5010 logical unit number.
390
400 number of frequency steps.
410 array of calculated frequencies.
420 array of measured total harmonic distortion.
430 sweep starting frequency.

```

Fig. 3-6 (cont). AA 5001 program example (4050A Series).

```

2190 END IF
2200 IF S$="AA5001" AND Error=704 THEN
2210   Error=4
2220 END IF
2230 IF Error=1 THEN
2240   Error="Display Overrange"
2250 END IF
2260 IF Error=2 THEN
2270   Error="Insufficient Input Level"
2280 END IF
2290 IF Error=3 THEN
2300   Error="Excessive Input Level"
2310 END IF
2320 IF Error=4 THEN
2330   Error="Unsettled Reading"
2340 END IF
2350 PRINT Error, "ADDRESS = ", Addr, "STATUS = ", Status
2360 RETURN
2370 END

```



```

440 freestop
450 toleran
460 counts
470 points
480 amplif
490 output amplitude of SG 5010.
OPERATING INSTRUCTIONS:
500 Connect output of SG 5010 to input of Device Under Test.
510 Connect output of DUT to input of AA 5001. Address of AA 5001
520 must be set to 28 and address of SG 5010 must be set to 25. If
530 addresses are different from these factory set addresses, then
540 variables aprim ( AA 5001 primary address ) and sspri ( SG 5010
550 primary address ) must be changed accordingly.
560 ERRORS:
570 No GPIB or tape error handlers are linked so 4041 prints default system
580 error messages and stops if such errors occur (instrument power is off
590 or tape capacity exceeded, etc.).
INSTRUMENT CONTROL:
600 Freestop:
610 Freestop:
620 INSTRUMENT CONTROL:
630 Freestop:
640 Freestop:
650 Freestop:
660 Freestop:
670 Freestop:
680 Freestop:
690 Freestop:
700 Freestop:
710 Freestop:
720 Freestop:
730 Freestop:
740 Freestop:
750 Freestop:
760 Freestop:
770 Freestop:
780 Freestop:
790 Freestop:
800 Freestop:
810 Freestop:
820 Freestop:
830 Freestop:
840 Freestop:
850 Freestop:
860 Freestop:
870 Freestop:
880 Freestop:
890 Freestop:
900 Freestop:
910 Freestop:
920 Freestop:
930 Freestop:
940 Freestop:
950 Freestop:
960 Freestop:
970 Freestop:
980 Freestop:
990 Freestop:
1000 Freestop:
1010 Freestop:
1020 Freestop:
1030 Freestop:
1040 Freestop:
1050 Freestop:

```

Fig. 3-7 (cont). AA 5001 program example (4041).



Fig. 3-7 (cont). AA 5001 program example (4041).

```

1060 Print #5:VRMS"amp1t,"BAL ON;OUT ON;DISP FREQ"
1070 For count=1 to nsteps
1080 Print #5:"FREQ";frecaray(count)
1090 Input prompt "SEND" #aa:thdaray(count)
1100 Next count
1110 Out_data: call printout(nsteps,frecaray,thdaray)
1120 i_unlock all instruments on the bus.
1130 Mbyte ren(0)/ren(1)
1140 End
1200 Sub lossweep(frecst,frecstop/nsteps var frecaray) local steps/stepsize/index/count
1210 Integer index/step
1220 Steps=nsteps-1
1230 Stepsize=(lst(frecstop)-lst(frecst))/steps
1240 Index=0
1250 For count=lst(frecst) to lst(frecstop) step stepsize
1260 Index=index+1
1270 frecaray(index)=10*count
1280 Next count
1290 Return
1300 End
1400 Sub printout(nsteps,frecaray,thdaray)
1410 Print using "FA4XFA" #2000:"FREQUENCY", "THD"
1420 Print using "20A" #2000: "-----"
1430 For count=1 to nsteps
1440 Print using "7J2A3X6.46A" #2000:frecaray(count), "Hz",thdaray(count), "%"
1450 Next count
1460 Return
1470 End
1500 Sub handler local #s:statbyt/addr/efias
1510 Dim #s to 60
1520 Efiar=0
1530 Poll statbyt/addr
1540 Input prompt "ID?ERR?" #address
1550 If #s#(8,6)="#A5001" and valc(#s,pos(#s,"ERR",1))=601 then efiar=1
1560 If #s#(8,6)="#A5001" and valc(#s,pos(#s,"ERR",1))=701 then efiar=2
1570 If #s#(8,6)="#A5001" and valc(#s,pos(#s,"ERR",1))=703 then efiar=3
1580 If #s#(8,6)="#A5001" and valc(#s,pos(#s,"ERR",1))=704 then efiar=4
1590 If efiar=1 then #s=#$"Display Overrange"
1600 If efiar=1 then #s=#$"Insufficient Input Level"
1610 If efiar=1 then #s=#$"Excessive Input Level"
1620 If efiar=1 then #s=#$"Unsettled Reading"
1630 Print using "FAL=FA2DL=FA3DL" #2000:#s,"ADDRESS = ",addr,"STATUS = ",statbyt
1640 Resume
1650 End

```





```

100 *****
110 ***** DEVICE GAIN VERSUS FREQUENCY *****
120 *****
130 *****
140 For 4050A Series: July 22, 1983
150 Revised: September 28, 1983
160 Copyright (c) 1983 Tektronix, Inc. All rights reserved. This
170 software is provided on an "as is" basis without warranty of
180 any kind. It is not supported.
190 This program may be reproduced without prior permission, in
200 whole or in part, by the original purchaser. Copies must
210 include the above copyright and warranty notice.
220 PURPOSE:
230 Records the total gain in decibels of a system to a leveled
240 input signal which is swept from 10 Hz-100 KHz in logarithmic
250 fashion. The total number of points is 21 counting endpoints.
260 The gain is referenced to the gain at 1 KHz. The results are
270 then plotted on the 4050A Series screen.
280 REQUIRED EQUIPMENT:
290 AA 5001 Programmable Distortion Analyzer.
300 SG 5010 Programmable 160 KHz Oscillator.
310 4050A Series Controller.
320 PROGRAM SEGMENT VARIABLES:
330 aaaddr AA 5001 primary address. Factory set to 28.
340 saddr SG 5010 primary address. Factory set to 25.
350 nsteps number of frequency steps.
360 freqarray array of calculated frequencies.
370 levarray array of measured levels.
380 freestrt sweep starting frequency.
390 freestop sweep stop frequency.
400 toleran tolerance for Delay Unit! Settled also algorithm.
410 counts number of counts for DUS algorithm in AA 5001.
420 -points number of readings to be within tolerance and
430 ampit output amplitude of SG 5010.
440 midfreq midband frequency.
450 OPERATING INSTRUCTIONS:
460 Connect output of SG 5010 to input of Device Under Test.
470 Connect output of DUT to input of AA 5001. Address of AA 5001
480 must be set to 28 and address of SG 5010 must be set to 25. If
490 addresses are different from these factory set addresses, then
500 variables aaaddr ( AA 5001 primary address) and saddr (
510 SG 5010 primary address ) must be changed accordingly.
520 ERRORS:
530 AA 5001 and SG 5010 addresses must be set to 28 and 25
540 respectively or program assignments of variables aaaddr
550 and saddr changed in program.
560 INSTRUMENT CONTROL:
570 Polls instruments on assigned addresses (AA 5001 and SG 5010).
580 *****
590 INIT
600 PAGE
610 aaaddr=28
620 saddr=25

```

Fig. 3-8. AA 5001 program example (4050A series).



Fig. 3-8 (cont). AA 5001 program example (4050A series).

```

730 Nsteps=21
740 DIM Freqaray(Nsteps),Leveray(Nsteps)
750 Freqstr=10
760 Freqstop=100000
770 toleran=0.1
780 Counts=1
790 points=6
800 Amplit=1
810 Midfreq=1000
820 titles="GAIN VERSUS FREQUENCY"
830 titles="Frequency in Hertz"
840 titles="Gain in dB"
850 ON SRQ THEN 2180
860
870
880 CALL Sweeplos(Freqstr,Freqstop,Freqaray)
890
900
910 MWRITE @P5,63:
920 MWRITE @P5,73,-84
930
940 MWRITE @17:
950
960
970
980
990
1000
1010
1020
1030
1040
1050
1060
1070
1080
1090
1100
1110
1120
1130
1140
1150
1160
1170
1180
1190
1200
1210
1220
1230
1240
1250
1260
1270
1280
1290
1300
1310
1320
1330
1340
1350

```



```

1360 PRINT USING 1370:S$
1370 IMAGE A/
1380 NEXT I
1390 MOVE 0,4
1400 PRINT "I
1410 VIEWPORT 20,120,20,85
1420 LOW=LEVARAY(I)
1430 FOR INDEX=1 TO N$TEPS
1440 IF LEVARAY(INDEX)<LOW THEN
1450 LOW=LEVARAY(INDEX)
1460 END IF
1470 NEXT INDEX
1480 HIGH=LEVARAY(I)
1490 FOR INDEX=1 TO N$TEPS
1500 IF LEVARAY(INDEX)>HIGH THEN
1510 HIGH=LEVARAY(INDEX)
1520 END IF
1530 NEXT INDEX
1540 J=-5
1550 FLAG=0
1560 DO
1570 J=J+5
1580 IF (HIGH)J AND HIGH<=J+5 THEN
1590 HIGH=J+5
1600 FLAG=1
1610 END IF
1620 EXIT IF FLAG
1630 LOOP
1640 J=5
1650 FLAG=0
1660 DO
1670 J=J-5
1680 IF LOW<J AND LOW=>J-5 THEN
1690 LOW=J-5
1700 FLAG=1
1710 END IF
1720 EXIT IF FLAG
1730 LOOP
1740 DIFF=HIGH-LOW
1750 MINIMUM 10,50,LOW,HIGH
1760 MOVE 10,HIGH
1770 DRAW 10,LOW
1780 DRAW 50,LOW
1790 DRAW 50,HIGH
1800 DRAW 10,HIGH
1810 FOR P=1 TO 4
1820 FOR Q=2 TO 10
1830 T=10*LG1(Q*10^P)
1840 MOVE T,LOW
1850 FOR T1=LOW TO HIGH STEP 5
1860 RMOVE 0,-0.01*HIGH
1870 RDKAM 0,0.02*DIFF
1880 MOVE T,T1
1890 NEXT T1
1900 NEXT Q
1910 MOVE P*10-0.75,LOW-0.1*DIFF
1920 PRINT "10"
1930 RMOVE 0.7,0.05*DIFF
1940 PRINT P
1950 MOVE T,LOW
1960 DRAW T,HIGH
1970 NEXT P
1980 MOVE P*10-0.75,LOW-0.1*DIFF

```

Fig. 3-8 (cont). AA 5001 program example (4050A series).



Fig. 3-8 (cont). AA 5001 program example (4050A series).

```

1990 PRINT "10"
2000 RMDVE 0.7,0.05*DI#
2010 PRINT P
2020 FOR HOR=LOW TO HI# STEP 5
2030 MOVE 4,HOR-0.01*DI#
2040 IF HOR=0 THEN 2070
2050 PRINT USING "3D.ZDZA":HOR;"BR"
2060 GO TO 2080
2070 PRINT USING "2A2D":HOR;"HOR"
2080 MOVE 10,HOR
2090 DRAM 50,HOR
2100 NEXT HOR
2110 MOVE 10*LG1(Frearay(1)),Levaray(1)
2120 FOR Count=2 TO NSteps
2130 IKRAM 10*LG1(Frearay(Count)),Levaray(Count)
2140 NEXT Count
2150 HOME
2160 END SUB
2170 I SRD Handler
2180 DIM ES(60)
2190 EFlas=0
2200 POLL Addr,Stabst;AaprIm;SPrIm
2210 GOSUB Addr OF 2230,2270
2220 GO TO 2290
2230 PRINT @AaprIm;"ID?ERR?"
2240 INPUT @AaprIm:ES
2250 Addr=AaprIm
2260 GO TO 2300
2270 PRINT @SPrIm;"ID?ERR?"
2280 INPUT @SPrIm:ES
2290 Addr=SPrIm
2300 L=POS(ES);ERR(1)
2310 Error=SEG(ES);L,10)
2320 Error=VAL(Error)
2330 ST=SEG(ES);8,6)
2340 IF ST="A5001" AND Error=601 THEN
2350 EFlas=1
2360 END IF
2370 IF ST="A5001" AND Error=701 THEN
2380 EFlas=2
2390 END IF
2400 IF ST="A5001" AND Error=703 THEN
2410 EFlas=3
2420 END IF
2430 IF ST="A5001" AND Error=704 THEN
2440 EFlas=4
2450 END IF
2460 IF EFlas=1 THEN
2470 ES=ES&"Display Overrange"
2480 END IF
2490 IF EFlas=2 THEN
2500 ES=ES&"Insufficient Input Level"
2510 END IF
2520 IF EFlas=3 THEN
2530 ES=ES&"Excessive Input Level"
2540 END IF
2550 IF EFlas=4 THEN
2560 ES=ES&"Unsettled Reading"
2570 END IF
2580 PRINT ES;"ADDRESS = ";Addr;"STATUS = ";Stabst
2590 RETURN
2600 END

```





Fig. 3-9. AA 5001 program example (4041).

```

100 *****
110 ***** DEVICE GAIN VERSUS FREQUENCY *****
120 *****
130
140 For 4041: July 22, 1983      Revised: September 28, 1983
150
160 Copyright (c) 1983 Tektronix, Inc. All rights reserved. This
170 software is provided on an "as is" basis without warranty of
180 any kind. It is not supported.
190 This program may be reproduced without prior permission, in whole
200 or in part, by the original purchaser. Copies must include the
210 above copyright and warranty notice.
220
230 PURPOSE:
240 Records the total gain in decibels of a system to a leveled
250 input signal which is swept from 10 Hz to 100 KHz in logarithmic
260 fashion. The total number of points is 21 counting the endpoints.
270 The gain is referenced to the gain at 1 KHz. The results are then
280 printed out on the 4041 printer.
290
300 REQUIRED EQUIPMENT:
310 AA 5001 Programmable Distortion Analyzer.
320 SG 5010 Programmable 160 KHz Oscillator.
330 4041 Controller (V2.0)
340
350 PROGRAM SEGMENT VARIABLES:
360 aa      AA 5001 primary address. Factors set to 28.
370 sprin   SG 5010 logical unit number.
380 aa      AA 5001 logical unit number.
390 sprin   SG 5010 logical unit number.
400 nsteps  number of frequency steps.
410 frefary array of calculated frequencies.
420 lvarary array of measured levels.
430 frefstn sweep starting frequency.
440 frefstop sweep stop frequency.
450 toleran tolerance for Delay Unit. Settled algorithm in AA 5001.
460 counts  number of counts for DUS algorithm in AA 5001.
470 points  number of readings to be within tolerance and points.
480 amp1it  output amplitude of SG 5010.
490 midfreq midband frequency.
500
510 OPERATING INSTRUCTIONS:
520 Connect output of SG 5010 to input of Device Under Test.
530 Connect output of DUT to input of AA 5001. Address of AA 5001
540 must be set to 28 and address of SG 5010 must be set to 25. If
550 addresses are different from these factory set addresses, then
560 variables sprin ( AA 5001 primary address) and sprin ( SG 5010
570 primary address ) must be changed accordingly.
580
590 ERRORS:
600 No GPIB or tape error handlers are linked so 4041 prints default system
610 error messages and stops if such errors occur (instrument power is off
620 or tape capacity exceeded, etc.).
630 INSTRUMENT CONTROL:
640 Polls all instruments on selected port.
650 *****
660 Begin main program segment
670 Init all
680 Select "spib0:"
690 On spr then call handler
700
710
720

```



Fig. 3-9 (cont). AA 5001 program example (4041).

```

730 Integer aaprm,sspr,m,aa,ss,nssteps,points
740 Set fuzz 7,1.0E-14,14,1.0E-64
750 Aaprm=28
760 Sspr,m=25
770 Aa=280
780 Ss=250
790 Nsteps=21
800 Dim frearay (nsteps), levaray (nsteps)
810 Frestrt=10
820 Frestop=1.0E+5
830 Toleran=0.1
840 Counts=1
850 Points=6
860 Amp1=1
870 Midfreq=1000.0
880 Titles="GAIN VERSUS FREQUENCY"
890 Xtitles="Frequency in Hertz"
900 Ytitles="Gain in dB"
910 Open #aa:"spib0(pri="&str$(aaprm)&")":
920 Open #ss:"spib0(pri="&str$(sspr,m)&")":
930 Open #2000:"prin":
940 Enable srs
950
960 Get frequency values for sweep.
970 Call losweep(frestrt,frestop,nsteps,frearay)
980
990 Initialize Instruments
1000 Hbte atn(mta,aaprm+m+32,sspr,m+32), "INIT",eoi,atn(unt,unt)
1010 Lock out the AA 5001 and the SG 5010 front panels.
1020 Hbte 110
1030 Set up AA 5001 for LEVEL function in volts, filters off, RMS Response.
1040 Print #aa:"FUNC VOLT:FILT OFF:RESP RMS"
1050 Set up AA 5001 to delay sending a reading until settled.
1060 Set tolerance, number of counts, and number of points for DUS algorithm.
1070 Print #aa:"DUS ON:TOL",toleran,"COUNTS",counts,"POINTS",points
1080 Set up SG 5010 for an RMS balanced output, out on, display freq.
1090 Print #ss:"VRMS",amp1,"BAL ON:OUT ON:DISP FREQ"
1100 Acquire gain at midband.
1110 Print #ss:"FREQ",midfreq
1120 Input prompt "SEND" #aa:ref
1130 For count=1 to nsteps
1140 Print #ss:"FREQ",frearay(count)
1150 Input prompt "SEND" #aa:levaray(count)
1160 Change reading to dB referenced to the gain at 1 KHz.
1170 Levaray(count)=20*log(levaray(count)/ref)
1180 Next count
1190 Out_data: call printout(nsteps,frearay,levaray)
1200 ! Unlock all instruments on the bus.
1210 Hbte ren(0),ren(1)
1220 End
1230 Sub losweep(frestrt,frestop,nsteps var frearay) local steps,stepsize,index,count
1240 Integer index,steps
1250 Steps=nsteps-1
1260 Stepsize=((st(frestop)-st(frestrt))/steps)
1270 Index=0
1280 For count=st(frestrt) to lt(frestop) step stepsize
1290 Index=index+1
1300 Frearay(index)=10*count
1310 Next count
1320 Return
1330 End
1340 Sub printout(nsteps,frearay,levaray)
1350 Print using "FAXFA" #2000:"FREQUENCY", "LEVEL"

```



```

1520 Print using "20A" #2000: "-----"
1530 For count=1 to nsteps
1540 Print using "7J2AX7.2G2A" #2000: frearray(count), "Hz", learray(count), "dB"
1550 Next count
1560 Return
1570 End
1600 Sub handler local es, stabyt, addr, refias
1610 Dim es to 60
1620 Eflas=0
1630 Poll stabyt,addr
1640 Input prompt "ID?ERR?" #addr:es
1650 If sess(es,8,6)="AA5001" #addr:es
1660 If sess(es,8,6)="AA5001" and valc(es,pos(es,"ERR",1))=601 then eflas=1
1670 If sess(es,8,6)="AA5001" and valc(es,pos(es,"ERR",1))=701 then eflas=2
1680 If sess(es,8,6)="AA5001" and valc(es,pos(es,"ERR",1))=703 then eflas=3
1690 If eflas=1 then es=es$Display Overrns#
1700 If eflas=2 then es=es$Insufficient Input Level
1710 If eflas=3 then es=es$Excessive Input Level
1720 If eflas=4 then es=es$Unsettled Reading
1730 Print using "FAL=FA2DL=FA3DL" #2000:es,"ADDRESS = ",addr,"STATUS = ",stabyt
1740 Resume
1750 End

```

Fig. 3-9 (cont). AA 5001 program example (4041).



```

100 ***** RIAA EQUALIZATION VERIFICATION *****
110 *****
120 *****
130 *****
140 For 4050A Series: July 22, 1983      Revised: September 28, 1983
150
160 Copyright (c) 1983 Tektronix, Inc. All rights reserved. This
170 software is provided on an "as is" basis without warranty of
180 any kind. It is not supported.
190 This program may be reproduced without prior permission, in
200 whole or in part, by the original purchaser. Copies must
210 include the above copyright and warranty notice.
220
230 PURPOSE:
240 Checks the accuracy of an RIAA equalization network on playback.
250 The frequency is swept from 20 Hz to 20 KHz, the input
260 amplitude to the network is varied according to the RIAA
270 response equation. The output of the DUT should remain at the
280 level that it was at 1 KHz. The measured results are graphed as
290 deviation from level at 1 KHz. The total number of points is 21.
300
310 REQUIRED EQUIPMENT:
320 AA 5001 Programmable Distortion Analyzer.
330 SG 5010 Programmable 160 KHz Oscillator.
340 4050A Series Controller
350
360 PROGRAM SEGMENT VARIABLES:
370 AA 5001 primary address. Factory set to 28.
380 sarrim
390 SG 5010 primary address. Factory set to 25.
400 nsteps
410 array of calculated levels. Measured in volts.
420 levelary
430 array of measured levels. Measured in volts.
440 rias
450 array of rias equalization parameters.
460 sweep starting frequency.
470 freestrt
480 sweep stop frequency.
490 toleran
500 tolerance for Delay Unit Settled algorithm.
510 counts
520 number of counts for DUS algorithm in AA 5001.
530 _points
540 number of readings to be within tolerance and
550 counts.
560 midamp
570 midband (1 KHz) output amplitude of SG 5010.
580
590 OPERATING INSTRUCTIONS:
600 Connect output of SG 5010 to input of Device Under Test.
610 Connect output of DUT to input of AA 5001. Address of AA 5001
620 must be set to 28 and address of SG 5010 must be set to 25.
630 If addresses are different from these factory set addresses,
640 then variables sarrim (AA 5001 primary address) and sarrim
650 (SG 5010 primary address) must be changed accordingly.
660 ERRORS:
670 AA 5001 and SG 5010 addresses must be set to 28 and 25
680 respectively or program assignments of variables sarrim
690 and sarrim changed in program.
700 INSTRUMENT CONTROL:
710 Polls instruments on assigned addresses (AA 5001 and SG 5010).
720 *****
730 INIT
740 PAGE
750 Apr 1983

```

Fig. 3-10. AA 5001 program example (4050A series).





Fig. 3-10 (cont). AA 5001 program example (4050A series).

```

730 Samps=25
740 Nsteps=21
750 DIM Freqaray (Nsteps), Levaray (Nsteps), Riasa (Nsteps)
760 Freqst=20000
770 Freqstop=20000
780 Toleran=0.1
790 Counts=1
800 Points=6
810 Midamp=1
820 Titles="RIAA EQUALIZATION VERIFICATION"
830 Xtitles="Frequency in Hertz"
840 Ytitles="Deviation in dB"
850 ON SRQ THEN 1980
860
870
880 CALL Riasaverl(Freqst,Freqstop,Nsteps,Freqaray,Riasa)
890
900
910 MBYTE GARRM+32,Sarrm+32:73,78,73,-84
920 MBYTE 95,63:
930
940 MBYTE 817:
950
960 I Set up AA 5001 for LEVEL function in volts, filters off, RMS.
970 PRINT GARRM:"FUNC VOLT:FILT OFF:RESP RMS"
980 I Set tolerance, number of counts, and number of points.
990 PRINT GARRM:"BUS ON:TOL ?;toleran?;COUNTS ?;Counts"
1000 PRINT GARRM:"POINTS ?;points"
1010 I Set up SG 5010 for RMS balanced output, out on, display freq.
1020 PRINT GARRM:"VRMS ?;Midamp?;BAL ON:OUT ON:DISP FREQ"
1030 I Acquire gain at 1 kHz.
1040 PRINT GARRM:"FREQ 1KZ"
1050 PRINT GARRM:"SEND"
1060 INPUT GARRM:Ref
1070 FOR Count=1 TO Nsteps
1080 PRINT GARRM:"AMPL ?;Midamp/Riasa(Count);:FFREQ ?;Freqaray(Count)
1090 PRINT GARRM:"SEND"
1100 INPUT GARRM:Levaray(Count)
1110
1120 I Calculate dB level from voltage readings for added accuracy.
1130 NEXT Count
1140 CALL Plotloop(Nsteps,Freqaray,Levaray,Titles,Xtitles,Ytitles)
1150
1160 CALL RENOFF
1170 CALL RENON
1180 OFF SRQ
1190 END
1200
1210 SUB Riasaverl(Freqst,Freqstop,Nsteps,Freqaray,Riasa)
1220
1230
1240
1250
1260
1270
1280
1290
1300
1310
1320
1330
1340
1350
1360
1370
1380
1390
1400
1410
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1430
1440
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1460
1470
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1500
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1600
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1930
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1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
2110
2120
2130
2140
2150
2160
2170
2180
2190
2200
2210
2220
2230
2240
2250
2260
2270
2280
2290
2300
2310
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2500
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2700
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2720
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2770
2780
2790
2800
2810
2820
2830
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2850
2860
2870
2880
2890
2900
2910
2920
2930
2940
2950
2960
2970
2980
2990
3000
3010
3020
3030
3040
3050
3060
3070
3080
3090
3100
3110
3120
3130
3140
3150
3160
3170
3180
3190
3200
3210
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3910
3920
3930
3940
3950
3960
3970
3980
3990
4000
4010
4020
4030
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4060
4070
4080
4090
4100
4110
4120
4130
4140
4150
4160
4170
4180
4190
4200
4210
4220
4230
4240
4250
4260
4270
4280
4290
4300
4310
4320
4330
4340
4350
4360
4370
4380
4390
4400
4410
4420
4430
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4600
4610
4620
4630
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4660
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4680
4690
4700
4710
4720
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4980
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6150
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6280
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6680
6690
6700
6710
6720
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6930
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6960
6970
6980
6990
7000
7010
7020
7030
7040
7050
7060
7070
7080
7090
7100
7110
7120
7130
7140
7150
7160
7170
7180
7190
7200
7210
7220
7230
7240
7250
7260
7270
7280
7290
7300

```



Fig. 3-10 (cont). AA 5001 program example (4050A series).

```

1350 Rias(Index)=10*Temp
1360 NEXT Count
1370 END SUB
1380 SUB PlotIDP(NSteps,Freqs,Lvars,Titles,XTitles,YTitles)
1390 PAGE
1400 WINDOW 0,130,0,100
1410 VIEWPORT 0,130,0,100
1420 PRINT "J"
1430 PRINT "J"
1440 FOR I=1 TO LEN(YTitles)
1450 S=SEG(YTitles,I,1)
1460 PRINT USING 1470:SS
1470 IMAGE A/
1480 NEXT I
1490 MOVE 0,4
1500 PRINT "I
1510 VIEWPORT 20,120,20,85
1520 LOW=-1
1530 HIGH=1
1540 DIF=HIGH-LOW
1550 WINDOW 10,50,LOW,HIGH
1560 MOVE 10,HIGH
1570 DRAW 10,LOW
1580 DRAW 50,LOW
1590 DRAW 50,HIGH
1600 DRAW 10,HIGH
1610 FOR P=1 TO 4
1620 FOR Q=2 TO 10
1630 T=10*LG1(Q*10^P)
1640 MOVE T,LOW
1650 FOR TIC=LOW TO HIGH STEP 0.1*DIFF
1660 RMOVE 0,-0.01*DIFF
1670 RDRAM 0,0.02*DIFF
1680 MOVE T,TIC
1690 NEXT TIC
1700 NEXT Q
1710 MOVE P*10-0.75,LOW-0.1*DIFF
1720 PRINT "10"
1730 RMOVE 0.7,0.05*DIFF
1740 PRINT P
1750 MOVE T,LOW
1760 DRAW T,HIGH
1770 NEXT P
1780 MOVE P*10-0.75,LOW-0.1*DIFF
1790 PRINT "10"
1800 RMOVE 0.7,0.05*DIFF
1810 PRINT P
1820 FOR HOR=LOW TO HIGH STEP 0.1*DIFF
1830 MOVE 4,HOR-0.01*DIFF
1840 IF HOR=0 THEN 1870
1850 PRINT USING "2A2D" :HOR
1860 GO TO 1880
1870 PRINT USING "2A2D" :HOR
1880 MOVE 10,HOR
1890 DRAW 50,HOR
1900 NEXT HOR
1910 MOVE 10*LG1(Freqs(1)),Lvars(1)
1920 FOR Count=2 TO NSteps
1930 DRAW 10*LG1(Freqs(Count)),Lvars(Count)
1940 NEXT Count
1950 HOME
1960 END SUB
1970 I SRD Handler

```



```

1980 DIM E$(60)
1990 Eflag=0
2000 FOLL Addr,StabstAappm:Sprrm
2010 GOSUB Addr OF 2030,2070
2020 GO TO 2390
2030 PRINT GAppm:"ID?ERR?"
2040 INPU GAppm:ES
2050 AddrAappm
2060 GO TO 2100
2070 PRINT GSprrm:"ID?ERR?"
2080 INPU GSprrm:ES
2090 Addr=Sprrm
2100 L=POS(E$,"ERR",1)
2110 Error$=SEG(E$,L,10)
2120 Error=VAL(Error$)
2130 S$=SEG(E$,8,6)
2140 IF S$="A5001" AND Error=601 THEN
2150   Eflag=1
2160 END IF
2170 IF S$="A5001" AND Error=701 THEN
2180   Eflag=2
2190 END IF
2200 IF S$="A5001" AND Error=703 THEN
2210   Eflag=3
2220 END IF
2230 IF S$="A5001" AND Error=704 THEN
2240   Eflag=4
2250 END IF
2260 IF Eflag=1 THEN
2270   E=C$;"Display Overrange"
2280 END IF
2290 IF Eflag=2 THEN
2300   E=E$;"Insufficient Input Level"
2310 END IF
2320 IF Eflag=3 THEN
2330   E=E$;"Excessive Input Level"
2340 END IF
2350 IF Eflag=4 THEN
2360   E=E$;"Unsettled Reading"
2370 END IF
2380 PRINT C$;"ADDRESS = ";Addr;"STATUS = ";Stabst
2390 RETURN
2400 END

```

Fig. 3-10 (cont). AA 5001 program example (4050A series).



Fig. 3-11. AA 5001 program example (4041).

```

100 *****
110 ***** RIAA EQUALIZATION VERIFICATION *****
120 *****
130 *****
140 *****
150 *****
160 *****
170 *****
180 *****
190 *****
200 *****
210 *****
220 *****
230 *****
240 *****
250 *****
260 *****
270 *****
280 *****
290 *****
300 *****
310 *****
320 *****
330 *****
340 *****
350 *****
360 *****
370 *****
380 *****
390 *****
400 *****
410 *****
420 *****
430 *****
440 *****
450 *****
460 *****
470 *****
480 *****
490 *****
500 *****
510 *****
520 *****
530 *****
540 *****
550 *****
560 *****
570 *****
580 *****
590 *****
600 *****
610 *****
620 *****
630 *****
640 *****
650 *****
660 *****
670 *****
680 *****
690 *****
700 *****
710 *****
720 *****
Select "SP1B0":
Init all
Begin main program segment
*****
Polls all instruments on selected port.
INSTRUMENT CONTROL:
or tape capacity exceeded, etc.).
error messages and stops if such errors occur (instrument power is off
No GPIB or tape error handlers are linked so 4041 prints default system
ERRORS:
Connect output of SG 5010 to input of Device Under Test.
Connect output of DUT to input of AA 5001. Address of AA 5001
must be set to 28 and address of SG 5010 must be set to 25. If
addresses are different from these factory set addresses, then
variables aarrim ( AA 5001 primary address ) and sarrim ( SG 5010
primary address ) must be changed accordingly.
OPERATING INSTRUCTIONS:
midband (1 KHZ) output amplitude of SG 5010.
number of readings to be within tolerance and points.
counts
number of counts for DUS algorithm in AA 5001.
tolerance for delay until Settled algorithm in AA 5001.
sweep stop frequency.
frequency starting frequency.
array of rias equalization parameters.
array of measured levels. Measured in volts, converted to dB.
array of calculated frequencies.
number of frequency steps.
AA 5001 logical unit number.
SG 5010 logical unit number.
array of measured levels. Measured in volts, converted to dB.
array of calculated frequencies.
number of frequency steps.
frequency starting frequency.
sweep stop frequency.
tolerance for delay until Settled algorithm in AA 5001.
counts
number of counts for DUS algorithm in AA 5001.
midband (1 KHZ) output amplitude of SG 5010.
PROGRAM SEGMENT VARIABLES:
aarrim AA 5001 primary address. Factory set to 28.
sarrim SG 5010 primary address. Factory set to 25.
aa AA 5001 logical unit number.
sa SG 5010 logical unit number.
nsteps number of frequency steps.
freesrt array of measured levels. Measured in volts, converted to dB.
levaray array of calculated frequencies.
levaray array of measured levels. Measured in volts, converted to dB.
freesrt sweep stop frequency.
toleran tolerance for delay until Settled algorithm in AA 5001.
counts number of counts for DUS algorithm in AA 5001.
points number of readings to be within tolerance and points.
midamp midband (1 KHZ) output amplitude of SG 5010.
CONNECT output of SG 5010 to input of Device Under Test.
CONNECT output of DUT to input of AA 5001. Address of AA 5001
must be set to 28 and address of SG 5010 must be set to 25. If
addresses are different from these factory set addresses, then
variables aarrim ( AA 5001 primary address ) and sarrim ( SG 5010
primary address ) must be changed accordingly.
ERRORS:
No GPIB or tape error handlers are linked so 4041 prints default system
error messages and stops if such errors occur (instrument power is off
or tape capacity exceeded, etc.).
INSTRUMENT CONTROL:
Polls all instruments on selected port.
*****
Begin main program segment
Init all
Select "SP1B0":

```





```

730 On srs then call handler
740 Integer aaprim,ssprim,aa,ss,ntsteps,points
750 Set fuiz 7,1.0E-14,14,1,1.0E-64
760 Aaprim=28
770 Ssprim=25
780 Aa=280
790 Ss=250
800 Nsteps=21
810 Dim frearay(ntsteps), levaray(ntsteps), riasa(ntsteps)
820 Frearst=20
830 Frearstop=2.0E+4
840 Toleran=0.1
850 Counts=1
860 Points=6
870 Midamp=1
880 Title$="RIA EQUALIZATION VERIFICATION"
890 Xtitle$="Frequency in Hertz"
900 Ytitle$="Deviation in dB"
910 Open $aa: "SP10(PRI=$str$(aaprim)&"):"
920 Open $ss: "SP10(PRI=$str$(ssprim)&"):"
930 Open $2000: "PRINT"
940 Enable srs
950 Get frequency values for sweep.
960 Call riasaver!(frearst,frearstop,ntsteps,frearay,rias)
970 Initialize Instruments
980 Mbyte atn(mta,aaprim+32,ssprim+32),"INIT",eo!atn(unt,unt)
990 Lock out the AA 5001 and the SG 5010 front panels.
1000 Mbyte lio
1010 Set up AA 5001 for LEVEL function in volts, filters off, RMS Response.
1020 Print #aa: "FUNC VOLT/FILT OFF;RESP RMS"
1030 Set tolerance, number of counts, and number of points.
1040 Print #aa: "DUS ON;TOL;/toleran,"COUNTS"/counts,"POINTS"/points
1050 Set up SG 5010 for an RMS balanced output, out on, display freq.
1060 Print #ss: "VRMS;/midamp,"BAL ON;OUT ON;DISP FREQ"
1070 Acquire sa in at 1 KHz.
1080 Print #srs: "FREQ I33"
1090 Input prompt "SEND" #aa:ref
1100 For count=1 to nsteps
1110 Print #srs: "AMP/;/midamp/rias(count),"FREQ"/frearay(count)
1120 Wait 0.5
1130 Input prompt "SEND" #aa:levaray(count)
1140 Calculate dB level from voltage readings for added accuracy.
1150 Levaray(count)=20*lg(st(levaray(count)/ref)
1160 Next count
1170 Call printout(ntsteps,frearay,levaray)
1180 ! Unlock all instruments on the bus.
1190 Mbyte ren(0),ren(1)
1200 End
1210 Sub riasaver!(frearst,frearstop,ntsteps var frearay,rias) local steps,stepsize,index,count
1220 Integer index,steps
1230 Steps=nsteps-1
1240 Stepsize=(st(frearstop)-st(frearst))/steps
1250 I19=(7.5E-5*2*#(1000.0)^2
1260 I29=(3.184E-4*2*#(1000.0)^2
1270 I39=(0.003184*2*#(1000.0)^2
1280 Ref=sspr*((1+I29)/(1+I19))*(1+I39))
1290 Index=0
1300 For count=st(frearst) to st(frearstop) step stepsize
1310 Index=index+1
1320 Frearay(index)=I0*count
1330
1340
1350
1360
1370
1380
1390
1400
1410

```

Fig. 3-11 (cont). AA 5001 program example (4041).



Fig. 3-11 (cont). AA 5001 program example (4041).

```

1420 T15=(7.5E-5*2**I*10^count)*2
1430 T24=(3.184E-4*2**I*10^count)*2
1440 T34=(0.003184*2**I*10^count)*2
1450 Temp=5*(1+(1+T24)/((1+T15)*(1+T34)))
1460 Riaa(index)=I*Temp
1470 Next count
1480 Return
1490 End
1600 Sub printout(nsteps,freqaray,levaray)
1610 Print using "FAZXA" #2000: "FREQUENCY", "DEVIATION"
1620 Print using "20A" #2000: "-----"
1630 For count=1 to nsteps
1640 Print using "7J2AX7.2G2A" #2000:freqaray(count),"Hz",levaray(count) / "dB"
1650 Next count
1660 Return
1670 End
1700 Sub handler local es
1710 Dim es to 60
1720 Eflag=0
1730 Poll stabyt,addr
1740 Input prompt "ID?;ERR?" #addr:es
1750 If sess(es,8,6)="AA5001" and valc(es,pos(es),"ERR",1))=601 then eflag=1
1760 If sess(es,8,6)="AA5001" and valc(es,pos(es),"ERR",1))=701 then eflag=2
1770 If sess(es,8,6)="AA5001" and valc(es,pos(es),"ERR",1))=703 then eflag=3
1780 If sess(es,8,6)="AA5001" and valc(es,pos(es),"ERR",1))=704 then eflag=4
1790 If eflag=1 then es=es*2 "Display Overrange"
1800 If eflag=2 then es=es*2 "Insufficient Input Level"
1810 If eflag=3 then es=es*2 "Excessive Input Level"
1820 If eflag=4 then es=es*2 "Unsettled Reading"
1830 Print using "FAL=FAZDL=FA3DL" #2000:es,"ADDRESS = ",addr,"STATUS = ",stabyt
1840 Resume
1850 End

```



\*\*\*\*\* TOTAL HARMONIC DISTORTION VERSUS OUTPUT POWER \*\*\*\*\*

For 4050A Series: July 22, 1983  
Revised: September 28, 1983  
Copyright (c) 1983 Tektronix, Inc. All rights reserved. This software is provided on an "as is" basis without warranty of any kind. It is not supported.

This program may be reproduced without prior permission, in whole or in part, by the original purchaser. Copies must include the above copyright and warranty notice.

PURPOSE:  
Records the total harmonic distortion of a system to a logarithmically increasing input signal at a frequency determined by variable testfreq.

The voltage is increased from the value of the variable testfreq until the value of the variable distortion is greater than or equal to the value of the variable maxdist. When this point is reached, the output of the SG 5010 is changed to the previous output and a new increment size is used. This technique allows for the definition of the knee of the curve. In order for the algorithm to produce useful results, the value of variable voltstop must produce a distortion equal to or greater than the value of the variable maxdist. The results are then plotted on the 4050A Series screen. The total number of points is 21.

REQUIRED EQUIPMENT:  
AA 5001 Programmable Distortion Analyzer.  
SG 5010 Programmable 160 KHz Oscillator.  
4050A Series Controller

PROGRAM SEGMENT VARIABLES:  
maxdist AA 5001 primary address. Factory set to 28.  
srrpm SG 5010 primary address. Factory set to 25.  
nsteps number of voltage steps.  
amarray array of programmed output levels.  
thdarray array of measured total harmonic distortion.  
outarray array of measured output.  
testfreq frequency at which Device Under Test is tested.  
voltstart starting voltage of sweep.  
voltstop sweep stop voltage.  
tolerance tolerance for Delay Until Settled algorithm.  
counts number of counts for DUS algorithm in AA 5001.  
points number of readings to be within tolerance and counts.  
maxdist maximum distortion allowed to define knee.  
load load impedance of DUT.

OPERATING INSTRUCTIONS:  
Connect output of SG 5010 to input of Device Under Test.  
Connect output of DUT to input of AA 5001. Address of AA 5001 must be set to 28 and address of SG 5010 must be set to 25. If addresses are different from these factory set addresses, variables srrpm ( AA 5001 primary address ) and srrpm SG 5010 primary address ) must be changed accordingly.

ERRORES:  
AA 5001 and SG 5010 addresses must be set to 28 and 25

100  
110  
120  
130  
140  
150  
160  
170  
180  
190  
200  
210  
220  
230  
240  
250  
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460  
470  
480  
490  
500  
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620  
630  
640  
650  
660  
670  
680  
690  
700  
710  
720

Fig. 3-12. AA 5001 program example (4050A series).



Fig. 3-12 (cont). AA 5001 program example (4050A series).

```

730 | respectively or program assignment of variables apply
740 | and sarrim changed in program.
750 |
760 | INSTRUMENT CONTROL:
770 | Polls instruments on assigned addresses (AA 5001 and SG 5010).
780 |
790 | *****
800 | Begin main program segment
810 INIT
820 PAGE
830 Aarrim=28
840 Sarrim=25
850 Nsteps=21
860 DIM Aarray(Nsteps), Thdaray(Nsteps), Outaray(Nsteps)
870 Voltstr=0.02
880 Voltstop=0.2
890 toleran=0.1
900 Counts=1
910 _points=6
920 _maxdist=1
930 Testfreq=1000
940 Rload=100000
950 Title=THD VERSUS OUTPUT POWER
960 Xtitle=Output Power in Watts
970 Ytitle=THU in Percent
980 ON SRR THEN 2530
990 |
1000 | Initialize Instruments
1010 MRYTE GARRIM+32, SARRIM+32:73,78,73,-84
1020 MRYTE 895,63:
1030 | Lock out the AA 5001 and the SG 5010 front panels.
1040 MRYTE @17:
1050 | Set up AA 5001 for THD function in percent, filters off, RMS.
1060 PRINT GARRIM:"FUNC THDP;FILL OFF;RESP RMS"
1070 | Set up AA 5001 to delay sending a reading until settled.
1080 | Set tolerance, number of counts, and number of points.
1090 PRINT GARRIM:"DUS ON;TOL _?_toleran;?_COUNTS _?_Counts
1100 PRINT GARRIM:"POINTS _?_points
1110 | Set up SG 5010 for test frequency, balanced output,
1120 | out on, display volts RMS.
1130 PRINT GARRIM:"FREQ _?_Testfreq;?_BAL ON;OUT ON;DISP VRMS"
1140 stepsize=(LGT(Voltstop)-LGT(Voltstr))/(Nsteps-1)
1150 PRINT GARRIM:"VKMS _?_Voltstr
1160 Aarray(1)=Voltstr
1170 |PRINT GARRIM:"FUNC VOLT;SEND"
1180 PRINT GARRIM:Outaray(1)
1190 PRINT GARRIM:"FUNC THDP;SEND"
1200 INPUT GARRIM:Thdaray(1)
1210 Index=1
1220 FOR Count=LGT(Voltstr)+stepsize TO LGT(Voltstop) STEP _stepsize
1230 Index=Index+1
1240 PRINT GARRIM:"VRMS _?_Count
1250 Aarray(Index)=10*Count
1260 PRINT GARRIM:"FUNC VOLT;SEND"
1270 INPUT GARRIM:Outaray(Index)
1280 PRINT GARRIM:"FUNC THDP;SEND"
1290 INPUT GARRIM:Thdaray(Index)
1300 IF Thdaray(Index)=?_maxdist THEN 1340
1310 NEXT Count
1320 IF Index=Nsteps THEN 1550
1330 |Resolve: Step back one step.
1340 IF Index=2 THEN
1350 Voltstr=Aarray(1)

```





Fig. 3-12 (cont). AA 5001 program example (4050A series).

```

1990 FLAG=0
2000 J=-1
2010 DO
2020 J=J-1
2030 IF Lox(J AND Lox=)J-1 THEN
2040 Lox=J-1
2050 FLAG=1
2060 ENH IF
2070 EXIT IF FLAG
2080 LOOP
2090 Decade=3
2100 MINIMUM Lox*10,Lox*10+Decade*10,Lox,Hi
2110 MOVE Lox*10,Hi
2120 DRAM Lox*10,Lox
2130 DRAM Lox*10+Decade*10,Lox
2140 DRAM Lox*10+Decade*10,Hi
2150 DRAM Lox*10,Hi
2160 FOR Q=2 TO 10
2170 I=10*LGT(Q*10^P)
2180 MOVE I,Lox
2190 FOR TIC=Lox TO Hi STEP 0.1*DiF
2200 RMV 0,-0.01*DiF
2210 RMV 0,0.02*DiF
2220 DRAM 0,0.02*DiF
2230 MOVE I,TIC
2240 NEXT TIC
2250 NEXT Q
2260 MOVE P*10-0.75,Lox-0.1*DiF
2270 PRINT "10"
2280 RMV 0.7,0.05*DiF
2290 PRINT P
2300 MOVE I,Lox
2310 DRAM I,Hi
2320 NEXT P
2330 MOVE P*10-0.75,Lox-0.1*DiF
2340 PRINT "10"
2350 RMV 0.7,0.05*DiF
2360 PRINT P
2370 FOR HOR=Lox TO Hi STEP 0.1*DiF
2380 MOVE Lox*10-4,HOR-0.01*DiF
2390 IF HOR=0 THEN 2420
2400 PRINT USING "2D.2D2A":HOR;"%"
2410 GO TO 2430
2420 PRINT USING "2A2D":HOR;"%"
2430 MOVE Lox*10,HOR
2440 DRAM Lox*10+Decade*10,HOR
2450 NEXT HOR
2460 MOVE 10*LGT(Outpar(1)),Thdpar(1)
2470 FOR Count=2 TO Nsteps
2480 DRAM 10*LGT(Outpar(Count)),Thdpar(Count)
2490 NEXT Count
2500 HOME
2510 END SUB
2520 I SRQ Handler
2530 DIM E$(60)
2540 EFlag=0
2550 POLL Addr,Stabst;AaprIm;SPrIm
2560 GOSUB Addr OF 2580,2620
2570 GO TO 2940
2580 PRINT gAaprIm;"ID?ERK?"
2590 INPUT gAaprIm:E$
2600 Addr=AaprIm
2610 GO TO 2650

```



Fig. 3-12 (cont). AA 5001 program example (4050A series).

```

2620 PRINT @SPRIME:ID?ERR?
2630 INPUT @SPRIME:ES
2640 Addr=SPRIME
2650 L=POS(ES)-ERR(,1)
2660 Error$=SEG(ES,L,10)
2670 Error=VAL(Error$)
2680 S$=SEG(ES,8,6)
2690 IF S$="A5001" AND Error=601 THEN
2700   Error=1
2710 END IF
2720 IF S$="A5001" AND Error=701 THEN
2730   Error=2
2740 END IF
2750 IF S$="A5001" AND Error=703 THEN
2760   Error=3
2770 END IF
2780 IF S$="A5001" AND Error=704 THEN
2790   Error=4
2800 END IF
2810 IF Error=1 THEN
2820   Error$="Display Overrange"
2830 END IF
2840 IF Error=2 THEN
2850   Error$="Insufficient Input Level"
2860 END IF
2870 IF Error=3 THEN
2880   Error$="Excessive Input Level"
2890 END IF
2900 IF Error=4 THEN
2910   Error$="Unsettled Reading"
2920 END IF
2930 PRINT ES, ADDRESS = "Addr", STATUS = "Stabyt"
2940 RETURN
2950 END

```



Fig. 3-13. AA 5001 program example (4041).

```

100 ***** TOTAL HARMONIC DISTORTION VERSUS OUTPUT POWER *****
110 *****
120 *****
130 *****
140 For 4041: July 22, 1983      Revised: September 28, 1983
150 Copyright (c) 1983 Tektronix, Inc. All rights reserved. This
160 software is provided on an "as is" basis without warranty of
170 any kind. It is not supported.
180 This program may be reproduced without prior permission, in whole
190 or in part, by the original purchaser. Copies must include the
200 above copyright and warranty notice.
210 PURPOSE:
220 Records the total harmonic distortion of a system to a logarithmically
230 increasing input signal at a frequency determined by variable testfreq.
240 The voltage is increased from the value of the variable voltstrt to
250 the value of the variable voltstop until the distortion is greater than
260 or equal to the value of the variable maxdist. When this point is
270 reached, the output of the SG 5010 is changed to the previous and a
280 new increment size is used. This technique allows the definition of
290 the knee of the curve. In order for the algorithm to produce useful
300 results, the value of variable voltstop must produce a distortion
310 equal to or slightly greater than the value of the variable maxdist.
320 The results are then printed out on the 4041 printer. The total number
330 of points is 21.
340 REQUIRED EQUIPMENT:
350 AA 5001 Programmable Distortion Analyzer.
360 SG 5010 Programmable 160 KHz Oscillator.
370 4041 Controller (V2.0)
380 PROGRAM SEGMENT VARIABLES:
390 aa 5001 primary address. Factory set to 28.
400 saddr 5010 logical unit number.
410 nsteps 5010 logical unit number.
420 array of programmed output levels.
430 thdarray array of measured total harmonic distortion.
440 outarray array of measured output.
450 testfreq frequency at which Device Under Test is tested.
460 voltstrt starting voltage of sweep.
470 voltstop sweep stop voltage.
480 tolerance for Delay Unit!! Settled algorithm in AA 5001.
490 counts number of counts for DUS algorithm in AA 5001.
500 points number of readings to be within tolerance and points.
510 maxdist maximum distortion allowed to define knee of curve.
520 load impedance of DUT.
530 OPERATING INSTRUCTIONS:
540 Connect output of SG 5010 to input of Device Under Test.
550 Connect output of DUT to input of AA 5001. Address of AA 5001
560 must be set to 28 and address of SG 5010 must be set to 25. If
570 addresses are different from these factory set addresses, then
580 variables saddr ( AA 5001 primary address ) and saddr ( SG 5010
590 primary address ) must be changed accordingly.
600 ERRORS:
610 No GPIB or tape error handlers are linked so 4041 prints default system
620 error messages and stops if such errors occur (instrument power is off
630 or tape capacity exceeded, etc.).

```



```

730 INSTRUMENT CONTROL:
740 Polls all instruments on selected port.
750 *****
760
770
780 Begin main program segment
790 Init all
800 Select "SP10:"
810 On srr then call handler
820 Long stepsize/count/voltsrt/voltsstop
830 Interse aaprim/sprim/aa/s/nsteps
840 Set fuzz 7.1.0E-14,15,1.0E-64
850 aaprim=28
860 sprim=25
870 aa=280
880 s9=250
890 nsteps=21
900 Dim array(nsteps),thdaray(nsteps),outaray(nsteps)
910 Long stepsize
920 Voltsrt=0.02
930 Voltsstop=0.2
940 Toleran=0.1
950 Counts=1
960 Points=6
970 Maxdist=1
980 Testfreq=1000.0
990 Rload=1.0E+5
1000 Title$="THD VERSUS OUTPUT POWER"
1010 Xtitle$="Output Power in Watts"
1020 Ytitle$="THD in Percent"
1030 Open aa:"SP10(PR1)=$str$(aaprim)&":
1040 Open s9:"SP10(PR1)=$str$(sprim)&":
1050 Open #2000:"PRINT"
1060 Enable srr
1070
1080 Initialize Instruments
1090 Hbvt stn(mta,aaprim+32,sprim+32),INIT,ea,iatn(unt,unt)
1100 Lock out the AA 5001 and the SG 5010 front panels.
1110 Hbvt 110
1120 Set up AA 5001 for THD function in percent, filters off, RMS Response.
1130 Print aa:"FUNC THDP:FILT OFF/RESP RMS"
1140 Set up AA 5001 to delay sending a reading until settled.
1150 Set tolerance, number of counts, and number of points for DUS algorithm.
1160 Print aa:"DUS ON/TOL, toleran, COUNTS, points, POINTS, points
1170 Set up SG 5010 for test frequency, balanced output, out on, display volts RMS.
1180 Print s9:"FREQ, testfreq, BAL ON/OUT ON/HISP VRMS"
1190 Stepsize=(st(voltsstop)-st(voltsrt))/(nsteps-1)
1200 Print s9:"VRMS,voltsrt
1210 array(1)=voltsrt
1220 Input prompt "FUNC VOLT:SEND" aa:outaray(1)
1230 Input prompt "FUNC THDP:SEND" aa:thdaray(1)
1240 Index=1
1250 For count=st(voltsrt)+stepsize to st(voltsstop) step stepsize
1260 Index=Index+1
1270 Print s9:"VRMS",10^count
1280 array(index)=10^count
1290 Input prompt "FUNC VOLT:SEND" aa:outaray(index)
1300 Input prompt "FUNC THDP:SEND" aa:thdaray(index)
1310 If thdaray(index)=maxdist then exit to resolve
1320 Next count
1330 If index=nsteps then goto finish
1340 Resolve: i Step back one steps.
1350 If index<2 then voltsrt=array(1) else voltsrt=array(index-1)

```

Fig. 3-13 (cont), AA 5001 program example (4041).





Fig. 3-13 (cont), AA 5001 program example (4041)

```

1360 Voltstop=amparam(index)
1370 Index=Index-1
1380 Remain=steps-Index
1390 StepSize=(1st(voltstop)-1st(voltstr))/(remain)
1400 For count=1st(voltstr)+stepSize to 1st(voltstop) step stepSize
1410 Index=Index+1
1420 Print #9:"VRMS":10*count
1430 Amparam(index)=10*count
1440 Input prompt "FUNC VOLT:SEND" #aa:outaray(index)
1450 Input prompt "FUNC THDP:SEND" #aa:thdaray(index)
1460 Next count
1470 Outaray=outaray*2/Load
1480 Finish: ! Test done.
1490 Out data: call printout(steps,outaray,thdaray)
1500 ! Unlock all instruments on the bus.
1510 Hbyte ren(0)/ren(1)
1520 End
1600 Sub printout(steps,outaray,thdaray) local count
1610 Print using "FA4XFA" #2000:"OUTPUT POWER", "THD"
1620 Print using "20A" #2000: "-----"
1630 For count=1 to steps
1640 Print using "7JAXX7.46A" #2000:outaray(count), "M",thdaray(count), "%"
1650 Next count
1660 Return
1670 End
1700 Sub handler local es,stabyt,addr,eflas
1710 Dim es to 60
1720 Eflas=0
1730 Poll stabyt,addr
1740 Input prompt "ID?ERR?" #addres
1750 If sess(es,8,6)="A5001" and valc(es,pos(es,"ERR",1))=601 then eflas=1
1760 If sess(es,8,6)="A5001" and valc(es,pos(es,"ERR",1))=701 then eflas=2
1770 If sess(es,8,6)="A5001" and valc(es,pos(es,"ERR",1))=703 then eflas=3
1780 If sess(es,8,6)="A5001" and valc(es,pos(es,"ERR",1))=704 then eflas=4
1790 If eflas=1 then es=est"Display Overrange"
1800 If eflas=2 then es=est"Insufficient Input Level"
1810 If eflas=3 then es=est"Excessive Input Level"
1820 If eflas=4 then es=est"Unsettled Reading"
1830 Print using "FAL=FA2DL=FAIDL" #2000:es,ADDRESS = "addr",STATUS = "stabyt"
1840 Resume
1850 End

```



## Warning

The following servicing instructions are for use only by qualified personnel. To avoid personnel injury, do not perform any servicing other than that contained in the operating instructions unless you are qualified to do so. Refer to General Safety Summary and Service Safety Summary prior to performing any service.



# THEORY OF OPERATION

## Introduction

Refer to the block diagram located in the foldout pages of this manual for a brief description and overall view of the AA 5001 operation. A detailed circuit description follows.

### 1 Input Amplifier

The input amplifier is designed for low noise and distortion. The input configuration is differential with single-ended output. This circuit provides good common mode rejection for suppression of ground loop currents and other unwanted signals which may be present on both input leads. The input stage is also protected to withstand at least 200 V rms on any input range.

The input amplifier gain is set by the logic circuitry at 0 dB (unity), +10 dB or +20 dB. The logic circuitry controls the gain so that the signal voltage at the output of the amplifier remains between 0.75 V and 3.0 V rms. An attenuator, prior to the amplifier, provides additional gain settings from -10 dB to -40 dB in 10 dB steps. The actual gain or attenuation selected depends on the input voltage level (or the setting of the INPUT RANGE switch if not in AUTO RANGE). For example, the 200 V input Range corresponds to 40 dB of attenuation and amplifier unity gain.

The input signal, from the front panel connections or the rear interface input (selected by front panel switch S6181) enters the input amplifier through P4070/J4070. Each input is ac coupled through C6070 or C4070. The signal then passes to the differential input attenuator hybrid, R2052. These resistors are laser trimmed and ratioed to maintain gain accuracy and common mode rejection. Relays K2052, K2060, K2061, K2070 and K2071 select attenuation from 10 dB steps. Frequency compensation of the attenuator is provided by C2061, C2051, and R2051.

When there is no attenuation (0 dB), DS3050 and DS3060 limit the input current under overload conditions. The current passing through the lamps warms their filaments, increasing their resistance. These lamps will sustain 120 Vac indefinitely and 200 Vac for at least 30 minutes. If the AA 5001 is subjected to greater overloads in the 0 dB attenuator position, the lamps act as fuses. When any attenuation other than 0 dB is selected, the resistance in the hybrid network provides current limiting. The inputs are clamped by Zener diodes VR4071 and VR4070 through four diode connected transistors Q4060, Q4061, Q4070 and

Q4071 and four diodes CR4072 through CR4075. When the post attenuator voltage on any scale exceeds about  $\pm 10$  V, one set of transistors turns on to limit the voltage at diode connected U4050A and B. The effect of the nonlinear capacitance of clamp diodes CR4072, CR4073, CR4074 and CR4075 is eliminated by maintaining a constant voltage across the diodes via a bootstrap arrangement from the outputs of U4050A and B.

The input signal is buffered by low noise amplifiers U4050A and U4050B. On the 0 dB through 40 dB attenuation ranges, these buffers provide unity gain. Relays K2050 and K2051 change the gain to +20 dB or +10 dB, respectively, by adding resistors R4056D or R4056E. Capacitors C4053 and C4062 provide frequency compensation.

The buffer outputs are combined into a single-ended output signal by U4061 (gain = 1.5). This signal is then routed to the automatic gain control circuitry (agc) and input amplifier level detector.

The gains of the combining stage and the buffers are controlled by hybrid resistor R4056. These resistors are laser trimmed and ratioed to insure gain accuracy and common mode rejection.

The signal level at the output of the input amplifier is detected by active rectifier U4041, in conjunction with CR4041 and CR4042. This full wave rectified signal is filtered by U4042A with C3045 and routed to the logic circuitry through J1060, pin 1. Recovery from overload is provided by VR3041. Resistor R4040 sets the filter gain so that, with 2 V rms into the AA 5001 input on the 2 V scale (3 V at pin 6 of U4061) the output at pin 1 of U4042 is 6 Vdc.

The gain setting driver relays, K2052 through K2071, are driven by the inverting amplifiers within U1060. Control signals from the logic circuitry enter the input board through P1060-J1060, pins 2 through 9, with one line at a time high (about +12 V). This logic high causes a low at the output of the inverting amplifier and closes the relay. When either K2052 activates directly or by Q1070 and U1050B, in 0 dB, +10 dB or +20 dB (pins 6, 7 or 8) is activated, AUTORANGE, the logic circuitry selects the proper input attenuation or gain to maintain 0.75 V to 3.0 V at U4061 pin 6, for inputs greater than approximately 50 mV.



Automatic Gain Control 2

The output of the input amplifier feeds the agc circuitry at levels between 0.75 V and 3.0 V for inputs greater than approximately 50 mV, and the agc automatically adjusts the signal to a constant 1.61 Vac. This is the reference level for the distortion measuring circuits.

The agc circuitry is composed of attenuator R4053, U5041, U5051, R4055, and amplifier U4051. The control element in the agc is a pair of light-dependent resistors (LDRs), U5041 and U5051. These devices consist of a light emitting diode and a semiconductor resistance cell in one package. As more control current is forced through the LEDs, the cells are illuminated more brightly and their resistance decreases. This causes more signal to shunt to ground.

The control circuitry for the agc consists of active rectifier, U402B with diodes CR4052 and CR4051. The filters are composed of U4062A and U4062B and associated components. This circuitry seeks to keep the voltage at the output, pin 6 of low noise operational amplifier U4051, to

approximately 1.61 V. This output voltage is varied to calibrate the THD measurements by adjusting R1051, the THD CAL control.

The output of U4051 is fullwave rectified by U4042B with diodes CR4051, CR4052 and integrated by U4062A and C5061 with the reference current from R5041 and R4042. Amplifier U4062B in conjunction with C5060, C5062, R5063, R5064 and C5063 provides additional filtering of the rectified voltage to reduce distortion introduced by the agc action. Transistor Q5071 provides the current drive necessary for the LDRs, while VR5051 linearizes the open loop gain of the agc loop to optimize transient response at all signal amplitudes.

Notch Filter 2

The leveled output from the agc (U4051) provides the input for the notch filter. The notch is formed by summing the output of an inverting band pass filter with the input signal. See Fig. 4-1. Operational amplifier U4020, and associated resistors and capacitors comprise a multiple feedback path inverting band pass filter. Amplifier U3010A is an

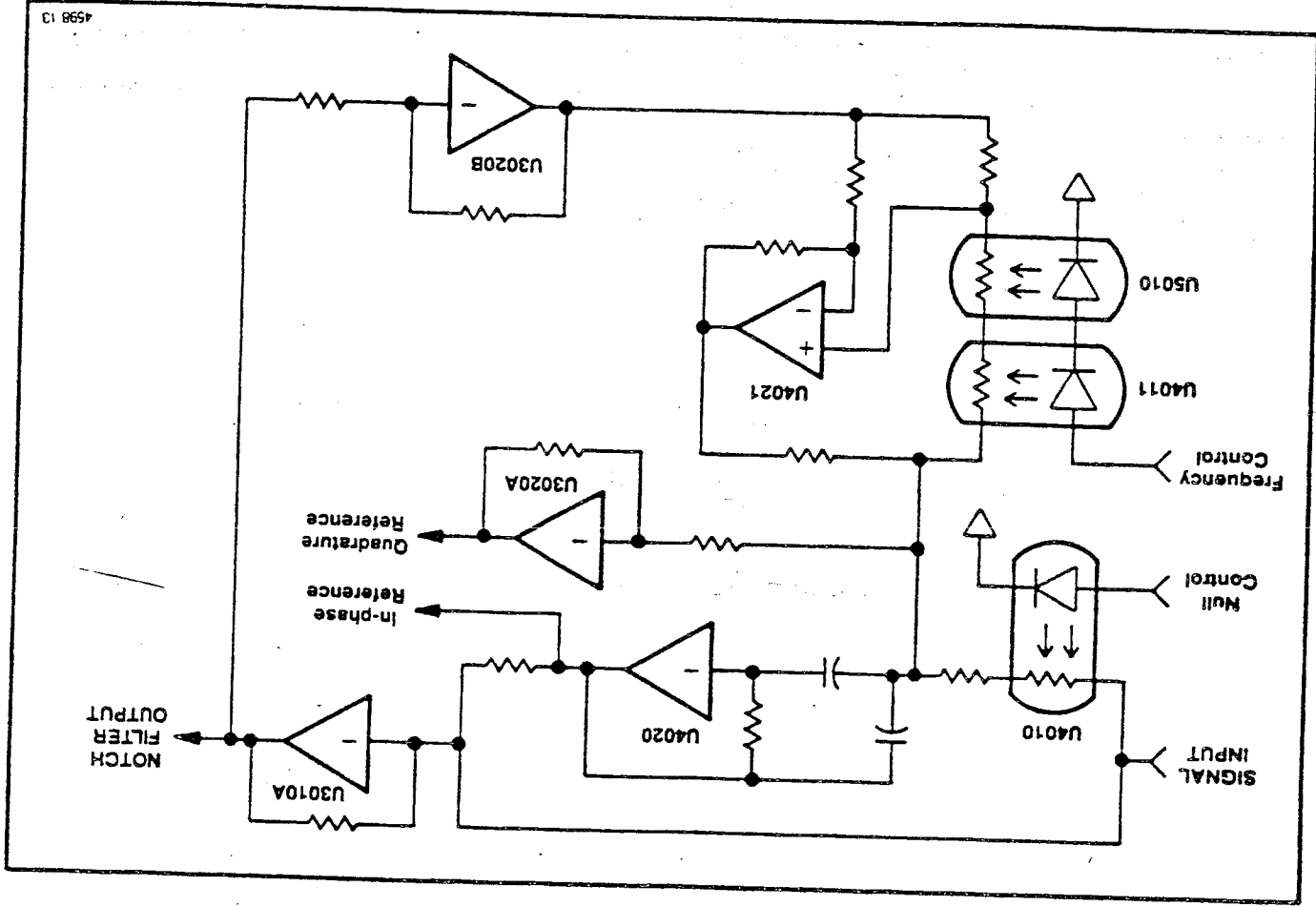


Fig. 4-1. Simplified notch filter.

4598 13





of Q1041 and Q1042. The frequency band is determined by measuring the period of the resulting square wave. When the input goes high, the outputs of U2050 change state. Assuming the Q outputs are high, the capacitors in the four rc networks (that are connected to the Q outputs of U2050) start to charge. The capacitor voltage on each network is compared via U2051 to a reference voltage developed across R2065, R3060, and R3061. When the input signal again goes high, the outputs of the comparators are latched in U2042. Simultaneously, the outputs of U2050 go low to discharge the capacitors in the rc networks in preparation for the next cycle.

If the period of the input is more than half the RC time constant, the capacitor voltage will be above the threshold and the comparator output is high at the transition. See Fig. 4-2. Discrimination of half decades is obtained by selecting the appropriate RC network via a CMOS switch (U2060) and comparing it to a higher reference voltage at pin 6 of U2051B. The last column in Table 4-1 shows the inputs for U2060. If the input frequency is below the band switch point of the selected decade (about 2.8 kHz for the 1 kHz to 10 kHz band) the output of U2051 is low. Resistors R2054, R3052, R2052, and R2050 provide a slight hysteresis at each decade edge, while R1515 provides hysteresis at half decade points. This hysteresis prevents random band switching when measuring signals close to the transition frequencies.

A bounce eliminator, U2041, prevents random band changes caused by grossly non-periodic signals. Capacitor C1041 sets the internal clock frequency of U2041 to approximately 100 Hz. The input state to U1400 must be stable for four clock cycles or 0.04 seconds for any change in output to occur.

The signal from the junction of R2026 and R3021 located on schematic 2 is squared by a Schmitt trigger, composed

inverting summer. Filter tuning is accomplished in half decade bands by switching both resistors and capacitors. Capacitors are switched each decade. Relay K4031 is energized for input frequencies below approximately 10 kHz. When below approximately 1 kHz, K4032 is also activated, while below approximately 100 Hz, K5030, K4032, and K4031 are used. K4030 is energized in the upper half of each decade reducing the tuning resistances by a factor of 3.2 thus scaling up the frequency range by a factor of 3.2. Continuous tuning within each half decade is achieved by adjusting the impedance of an electronic resistor (U4021A and B) with LDR opto isolators U4011 and U5010. As the LDR resistance rises, the electronic resistor value decreases, at the junctions of the outputs of R3026 and R5033, raising the filter frequency.

This circuit technique, although unusual, provides a good compromise between residual noise and distortion sources inherent in U4021, and LDR's U4011 and U5010.

U3028 feeds back a portion of the notch output to the electronic resistor keeping the Q of the bandpass filter nearly constant, as it is tuned.

Minor variations in the gain of the band pass filter (which causes incomplete cancellation of the fundamental) are compensated by a third LDR, U4010. Components C4021, R5032 and C5031 provide additional gain compensation. Drive signals for the LDRs come from the control loop circuitry. Synchronization signals, to run the control loops, come from the outputs of U4020 and U3020A.

### 5 Frequency Band Discriminator



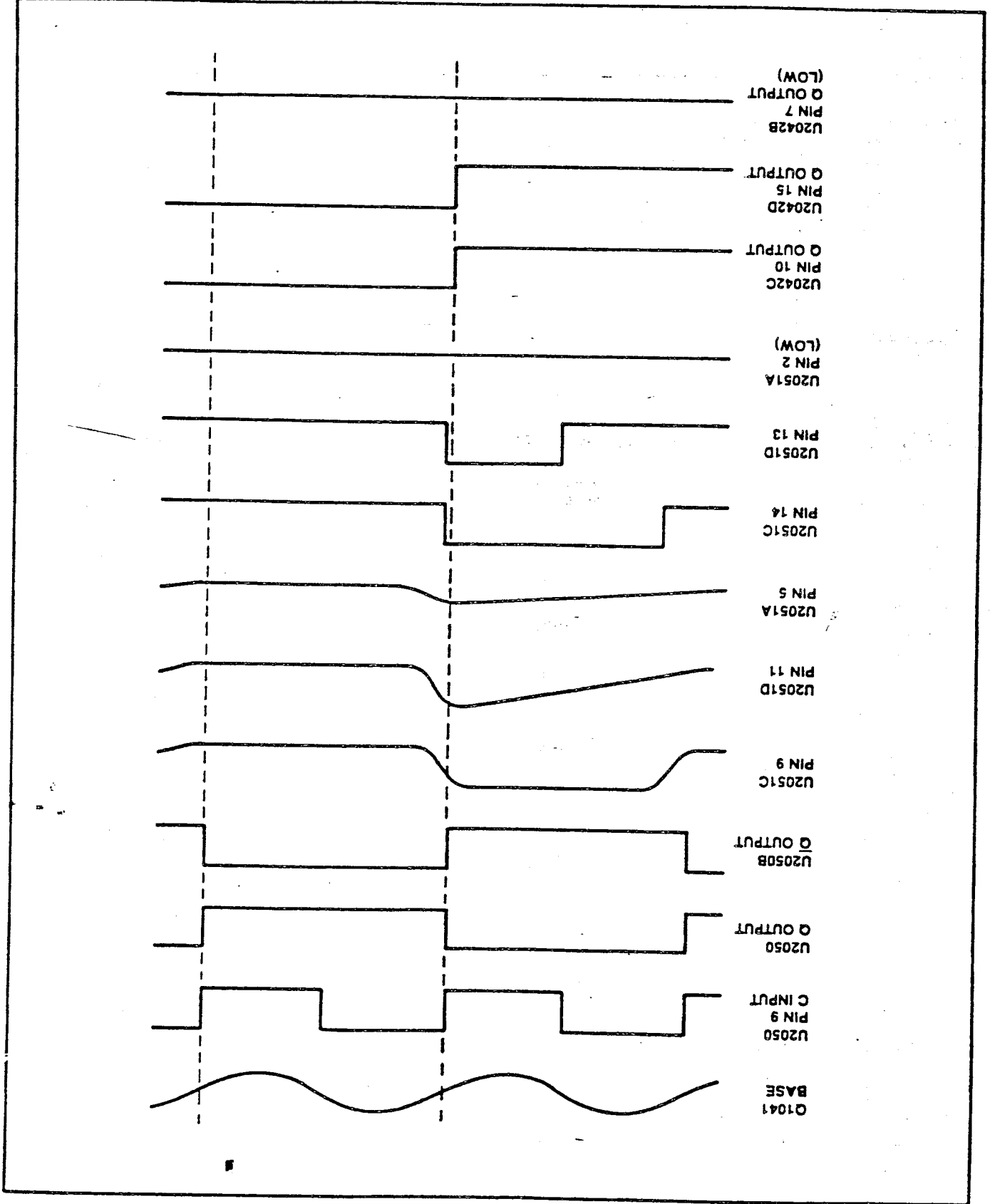


Fig. 4-2. Frequency band discriminator.



12 to 14 & 2 to 15	0 0	12 to 14 & 2 to 15
13 to 14 & 2 to 15	1 0	13 to 14 & 2 to 15
12 to 14 & 1 to 15	0 1	12 to 14 & 1 to 15
13 to 14 & 1 to 15	1 1	13 to 14 & 1 to 15
Logic Level Pins 11, 10		Internal Connections Pins

Table 4-2  
INTERNAL CONNECTIONS IN U1010 DEPENDING  
ON LOGIC STATES OF PINS 10 AND 11

The gain of the frequency control integrator is increased by Q2023 in all but the lowest frequency decade. Components VR2022, VR2023, R2018, C2010, CR2024, and CR2025 help speed the frequency control integrator for large control errors. VR4010 linearizes the open loop gain of the frequency control loop.

These outputs are integrated by U2020A, for the amplifier control loop and U2020B for the frequency control loop, buffered by Q2021 and Q2024, to drive the respective LDR opto-isolators in the notch filter. The net dc polarity of the signals at pins 15 and 14 determine, after passing of through integrators U2020A and U2020B, the direction of frequency change and amplitude change necessary to properly set the notch frequency and null the fundamental. Adjustments R1023 and R1031 trim out the effects of offsets in the operational amplifiers enabling adjustment of the loops for best nulling of the fundamental frequency. When stabilized, the dc signal at pins 14 and 15 of U1010 is essentially 0 V.

Chronously demodulated in-phase and quadrature components of the fundamental, present in the notch output signal.

Fin (Hz)	U2042A pin 3	U2042C pin 10	U2042D pin 15	U2042B pin 7	U2060 input pin no.
10-28	L	H	H	H	4
28-95	H	H	H	H	4
95-280	L	H	H	L	12
280-950	H	H	L	L	12
950-2.8K	L	H	L	L	14
2.8K-9.5K	H	H	L	L	14
9.5K-28K	L	L	L	L	13
28K-100K	H	L	L	L	13

Table 4-1  
TRUTH TABLE FOR U2042 OUTPUTS

As stated earlier, the in-phase component of the fundamental derived from the output of the bandpass filter U4020 (located on diagram 2) feeds pin 2 of U1020A. This circuitry forms a CMOS compatible logic signal to drive the CMOS multiplexer, U1010. The quadrature component of the fundamental derived from U3020A (diagram 2) similarly feeds pin 6 of U1010B. The switching arrangements of U2020 are shown in Table 4-2. The input to U2020A is switched between the inverted (pins 1 and 13) and the normal (pins 2 and 12) output of the notched filter at rate and phase determined by the in-phase signal at pin 10. The input to U2020B is also switched between the normal and inverted inputs to U1010 at a rate and phase determined by the quadrature signal at pin 11. The outputs of U1010 represent the syn-

The notch filter output is amplified by U3010B and U1011B. A total of 50 dB of gain is provided by these amplifiers. Differential input to the demodulators (U1010) is provided by U1011A. The output of this amplifier stage is rectified by CR1010 and CR1011. This signal is amplified by Q2010 and filtered by C2011 to control the resistance of FET Q2011, thus providing automatic gain control. This loop serves to optimize and level the input to the demodulators that generate the tuning and nulling error voltages. The amplifier gain is raised by Q2012 in all but the lowest fundamental frequency decade.

The notch filter is controlled by demodulating the in-phase and quadrature phase (shifted 90 degrees) components of the notch filter output referenced to the input fundamental signal. See Fig. 4-1. The in-phase reference inputs to pin 2 of U1020A, and the quadrature phase reference inputs to pin 6 of U1020B. When the notch frequency is correctly tuned, there is no quadrature phase component at the notch filter output. When the fundamental null (maximum amplitude rejection) is adjusted correctly, there is no in-phase component in the notch filter output.

Notch Filter Control



Logic Level	Total Gain Through Dist Amp	U2041 Gain	Internal Connections
0 0	+6 dB	0 dB	13 to 12 and 3 to 1
0 1	+26 dB	0 dB	13 to 14 and 3 to 5
1 0	+46 dB	0 dB	13 to 15 and 3 to 2
1 1	+66 dB	+20 dB	13 to 11 and 3 to 4

Table 4-3  
GAIN AND SWITCHING THROUGH U2031

The averaging rectifier is U2030A with diodes CR2031 and CR2032. The rectified output is smoothed and filtered by U2040B, C1040, and associated components. The average detector output connects to U2040A via Q3040 in the average response mode, overriding the rms converter.

After filtering, the signal is converted to a dc voltage by both rms and average techniques. Rms conversion is accomplished in U3031 (pin 10 out) using an implicit computing approach. The averaging capacitor is C3032. A low pass filter, U2040A, reduces readout jitter due to low frequency noise or ripple.

the state of the EXT control signal.

Output from the highpass filter, U4020B, connects to the front panel function output connector and the Cy channel of U3020. The AUXILIARY INPUT on the front panel connects to the Cx input through protection components R3022, CR4020, and CR4021. U2030B connects to either the AUXILIARY INPUT or the output from U4020B depending upon

The highpass filter (three pole 400 Hz Butterworth) is composed of U4020B, C4012, C4011, C4010, R4012, R4010, and R4011. This filter is driven by U4020A. When the highpass filter is disabled, U3020 connects pins 1, 13, 14, and 15 thus shorting the output of U4020A directly to the input of U4020B. R4013, R4014, and C4013 provide 10 Hz response compensation for low frequency accuracy.

ON CHANNELS				
B	A	X0	X1	X2
0	0	0	1	1
0	0	1	1	1
0	0	1	0	1
1	1	1	0	1
		Y0	Y1	Y2
		WEIGHTING	BANDPASS	80 KHZ LOWPASS
			Y3	330 KHZ LOWPASS

Table 4-4  
TRUTH TABLE FOR U1021

The weighting filters consist of U2023A, U2023B, U3021B, U3021A and associated resistors and capacitors. The signal from the distortion amplifier passes through the 330 KHz filter before passing to the remaining filters. Output from the filters is multiplexed by U1021 to the input of buffer, U4020A. Table 4-4 is a truth table for U1021.

The output of the distortion amplifier enters the main board through J1042 driving the weighting filters and the distortion amplifier ranging level detector. The detector, composed of U4030A and U4030B, full wave rectifies and filters the distortion amplifier output. This dc signal goes to the logic board to control auto-ranging of the distortion amplifier.

**Filters and AC-DC Converters (Standard Instruments Only)**

The distortion amplifier gain is controlled by multiplexer U2031. The input to U2030B, attenuated by R2036, R2037 or R2041 is supplied from U2031. See Table 4-3. A gain of +46 dB is provided by U2030A and B. The output of U2030A supplies a 4 V rms full scale signal to the filters.

Multiplexer U2040, selects the input source for the distortion amplifier. The four sources are: input stage pins 5 and 15, input stage less 10 dB pins 1 and 13 (through R2033 and R2032), THD notch filter pins 2 and 4, and IMD pins 12 and 15. Control of U2040 is through the level and IMD switches, as well as the output of U3021A as shown on the schematic. In the IMD mode, Q2042 turns on. This action shorts the THD input to U2040 to prevent possible crosstalk. In both the THD and IMD, Q2041 also turns off, to prevent crosstalk.

This circuitry amplifies the distortion components from the THD notch filter or the IMD section, as well as providing additional gain for the three lowest input ranges in level function.

**Distortion Amplifier**





**Filters and AC-DC Converters (Option 02 Instruments Only)**



The output of the distortion amplifier enters the main board through J1042 to drive the filters and the distortion amplifier ranging level detector. This detector, composed of U430A and U4030B, full wave rectifies and filters the distortion amplifier output. This dc signal goes to the logic board to control the distortion amplifier autorangeing.

The filters consist of U2023A, U2023B, U2021B, U2040A, U2040C, and U2040D with associated resistors and capacitors. The signal from the distortion amplifier passes through the 330 kHz filter before passing to the 80 kHz LO PASS and AUDIO BAND PASS filters. The weighting filter input is taken directly from the distortion amplifier output. R2035 provides gain calibration adjustment for the CIR weighting filter. Output from the filters are multiplexed by U1021 to the input of buffer U420A. Table 4-4 is a truth table for U1021.

The high pass filter (three pole 400 Hz Butterworth) is composed of U4208B, C4012, C4011, C4010, R4012, R4010, and R4011. This filter is driven by U420A. When the high pass filter is disabled, U3020 connects pins 1, 13, 14, and 15, shorting the output of U4208B directly to the input of U4208B. Components R4013, R4014, and C4013 provide 10 Hz response compensation for low frequency accuracy.

Output from the high pass filter, U4208B connects to the front panel FUNCTION OUTPUT connector and the Cy channel of U3020. The AUXILIARY INPUT, on the front panel, connects to the Cx input through protecting components R3022, CR4020, and CR4021. U2030B connects to either the AUXILIARY INPUT or the output from U4208B, depending upon the state of the EXT control signal.

After filtering, the signal is converted to a dc voltage by both rms and quasi-peak techniques. Rms conversion is accomplished in U3031 (pin 10 out) using an implicit computing approach. The averaging capacitor is C3032. A low pass filter, U2021A, reduces readout jitter due to low frequency noise or ripple.

The quasi-peak converter consists of full wave rectifier U2040B, peak detector U4031 and U3030A, and averager U3030B and their related circuitry. The input to the full wave rectifier is normally connected through R2022, except for the special case of simultaneous CCR weighting filter and quasi-peak response selections. In this case, Q2021 turns on directly connecting the output of the CCR weighting filter from U2040A to the full wave rectifier. This causes a gain calibration shift of the weighting filter, depending upon the response selection. With RMS response, the 0 dB fre-

quency is nominally 2.0 kHz. However, with quasi-peak response, it shifts to 1.0 kHz.

The output from the full wave rectifier, U2040B, passes to pin 2 of U4031. This circuitry rapidly charges C3053 to the peak value of the input waveform. This peak voltage is referenced to the input through U3030A with R4055, providing gain calibration adjustment. U3030B, C3052, and R3033 low-pass filter the charged peaks on C3053 and pass the signal on to the peak hold circuit, composed of U3030D and U3030C.

The purpose of the peak hold circuit is to allow short peak pulses to be accurately measured and displayed on the digital readout. Capacitor C3038 is charged to positive peaks through CR4033 until U3030D inputs at pins 12 and 13 are nearly equal. C4031 is also charged through CR4034. When the peak disappears, CR4033 reverse biases, and C3038 maintains the peak voltage which is buffered through U3030C and connected to the converter output through Q3040 and U2021A. The voltage across C4031 decays through R4035 generating approximately 1 second time delay. The voltage across C3038 remains constant until the voltage across C4031 drops to about 7 V below the level on C3038. C3038 then discharges through Q4030, operating as a low leakage zener diode. The quasi-peak detector output connects to U2021A via Q3040, in the quasi-peak response mode, overriding the rms converter.

**8** **dB Converter**

The dB section is fed by the dc output voltage from the selected detector. Shown on this schematic are the dB converter, dB/Volts switch, offset generator, dB ratio circuit, and a voltage reference.

The dB converter consists of quad operational amplifier U4111, transistor array U5101 and associated circuitry. The input to the converter is a 0.4 V dc signal from the selected detector and a 6 V reference. The output is a dc signal at U4111 pin 1. This signal is proportional to the log of the ratio of the dc input signal to the reference voltage as described in the relationship:

$$E = K \times \log \frac{I_C \text{ for U5101A}}{I_C \text{ for U5101B}}$$

K is a constant and I<sub>C</sub> is the noted collector current. The converter output is zero when the input voltage is 1.549 V, with a scale factor of -100 mV/dB.

Operational amplifier U4111D provides a constant collector current in U5101B while holding the collector voltage at 0. The collector voltage of U5101A is held at 0 V by the action of U4111C. The collector current in U5101A varies with the input voltage. When the two collector currents are



equal (at  $V_{in} = 1.549$  Volts), U510A pin 2 is at 0 V and U411C pin 8 is at 0 V. The offset voltage of the differential pair and U411A is adjusted by R810 (0 dB Adjust), which sets the 0 dB output level. Compensation for the offset voltage of U411C (-40 dB Adjust) is provided by R809. This provides correct log conformity at low input voltages. Inversion of the dB output is provided by U411A. Pin 1 of U411A also provides the dB voltage to the bar graph display.

The three remaining transistors in U5101 serve as heaters to maintain the differential pair (U510A and B) at a constant junction temperature. The voltage at U5101 pin 3 is proportional to the internal temperature. The voltage at U5101 is compared with the reference voltage and any error is amplified by U411B. The amplified error signal drives Q311 which supplies current to the heater transistors. The -20 dB Adjust, R2161, sets the internal junction temperature of the differential pair for the correct scale factor.

### 8 dB Offset Generator

The offset generator consists of U4121, U7101 and R7101. This circuitry provides a dc offset voltage that is added to the log converter output at the input of operational amplifier U4121C. This voltage is set by input from the logic section and corrects dB measurements for the overall gain in the signal path.

The reference voltage is divided by R7101 into six offset voltages. Multiplexer U7101 selects one of these six voltages (or ground) and supplies it to U4121D. The gain setting resistor for U4121D, as well as a resistor in series with its output, is included in R7101. The offset output is supplied to U4121C through R8111.

This signal is routed to U2151, a multiplexer, which selects the db-processed voltage (+10 mV/dB) or the voltage directly from the selected detector. This voltage is supplied to the DVM section. In the distortion modes, R3173 provides a small offset so that the 0 dB reference is changed from 0.775 V (0 dBm) to 1 V corresponding to 100%. In the dB ratio mode, U4121C also adds the stored reference voltage from the dB section supplied via pin 5 of U2151.

### 8 dB Ratio Circuitry

The dB ratio circuitry allows selection of any input voltage as the 0 dB reference. This is accomplished by adding a dc offset voltage from pin 15 of R7121 to pin 9 of U4121 through multiplexer U2151C. This causes 0 V at pin 8 of U4121C at the desired reference input voltage.

Amplifiers U6121C and D with resistor network R7121 form a digital-to-analog converter which supplies the dc offset.

set to the input of U4121C. This converter is driven by an 1 bit binary counter composed of U6111 and U7111. The counter is controlled by dual flip-flop U7161B which is supplied with a clock signal from the gated oscillator composed of U7151A and B.

When the dB ratio button is pushed (grounded), the debounce circuit, composed of U7151C and D, causes pin 1 of U7161A to go high. A short time later, determined by R8131 and C8135, pin 4 of U7161A goes high, terminating the high at pin 1. A positive pulse appears at U7161 pin 1. This allows the oscillator to start. The oscillator increments the counters changing the voltage offset. When the 0 dB reference button is pushed, the counter starts with the most negative voltage offset and increments in the positive direction. The output of U4121C connects to comparator U6121B. When the output of U4121C is 0 V, U6121B pin 7 goes high, causing U7161B pin 12 to go low at the next clock pulse. This action stops the oscillator. Future dB readings are referenced to this voltage. Pin 1 of U6121A goes positive a short time before U6121B pin 7. This switches the oscillator to a lower frequency through Q8161 and C7135 to prevent the circuits from overshooting the correct value.

### 8 6 V Reference

A 6 V reference voltage to the dB converter, offset generator, dB section, and dvm is provided by U4121A and VR2143.

### 44 DVM

The DVM section accepts the dc voltage from the dB converter or directly from the ac selected to dc converter and drives the digital display. The dvm input is proportional to the input signal voltage, the percent distortion or the log (dB) of the selected function. An LSI analog-to-digital converter with display drivers, U2050, drives the respective segments in LED display. Overrange indication is supplied internally in U2050. Reference voltage adjustment for the correct full scale reading is provided by R2064. Other external components support the internal operation of U2050.

The most significant LED module, DS1022, is controlled by U1060D and Q1060. This digit displays blank, 1 or 0. The 0 is displayed only in the 0.2% distortion range.

If a decimal point is needed in LED display DS1021, pin 2 of U1060A is low. This assures that pin 11 of U1060D is also low and illuminates the two segments comprising the one (1) in the most significant digit module, DS1022. Pin 19 of U2050 is high when a 0 is required and low when a 1 is required. The one is changed to a zero by illuminating an additional four segments of DS1022. The minus sign to the



U7021A which prevents the underrange LED from being illuminated. Pin 1 of U5081B is low when the input signal is lower than the input attenuator range. Pin 6 of U7021B is high in the most sensitive range. The up-down counter counts only when pin 5 is low. This occurs when the input signal level is higher than the attenuator range and the unit is not in the least sensitive position, or when the input signal is lower than the input attenuator range and the unit is not in the most sensitive range. The overrange and underrange LEDs are illuminated through Q2181 and Q2183 respectively. When the bases of these transistors are high, through the outputs of U7021A and U7021B, the lights are illuminated. The increase range and decrease range lights are also controlled by the distortion amplifier gain in the level mode.

U3021 decodes the odd 10 dB steps in the input stage gain and supplies this information to the distortion amplifier control and to U5011 for decimal point and offset formatting purposes.

Distortion amplifier gain is controlled in a manner similar to the input circuitry gain. U5081C, and U5081D are the level comparator and U7071A, U7071B, and U7071D perform the enable gating function.

The gain control input for the distortion amplifier is selected by U7041, a 4 bit and/or selector. In the level mode pin 9 is high, pin 14 is low, and pins 6, 4, and 2 are routed to the outputs. This selects the Input Level Range Switch, S4171, as the gain control input. In the distortion modes, pin 14 is high, 9 is low and 7, 5, and 3 are connected to the output. The distortion range switches now control the gain.

The signals from and to U7021C control the switching of U7041. A dc voltage proportional to the output of the distortion amplifier connects to pin 11 of U5081D. The operation of U5081 and U7071 are identical as described for the input stage up/down counter. These gates control up/down counter, U7061, for the distortion amplifier gain. A three-to-eight decoder driver, U5071, supplies decimal output for the distortion amplifier gain control circuitry.

A binary adder, U5011, shown on schematic 12, sums the gain of the input stage and the distortion amplifier. Pins 4, 7, 5, 3 and 6 provide input stage gain information. This sum is decoded by U5021, and passes through CR5031, CR5033 and CR5037. These diodes drive U3021B and U4061 to operate the  $\mu$ V, mV, and Volts annunciator LEDs. The control source for the decimal points is selected by U3041, a 4 bit and/or selector which operates as a multiplexer. In the volts mode, the decimal points are controlled by the decoded decimal information from U5021 and the

left of the most significant digit is used only in the db mode. Q1042 prevents the minus sign from illuminating in any other mode.

The ten operational amplifiers, U3050A, B, U3051 and U3062 comprise the drivers for the bar graph display. The analog signal from the db converter is applied to the negative inputs of these amplifiers. The input resistance dividers are selected so that only one operational amplifier at a time is operating in the linear region. There is approximately 2.5 dB between each segment, with a slight overlap from one segment to the next.

## Display Board

The four LED digit display modules and the sign module are illuminated by lowering the cathode voltages. The display module anodes and the state LEDs are operated from +5 V.

Pins 11 through 20 of DS1010, the bar graph display, are connected to -15 V. Pins 1 through 10 are driven by operational amplifiers in conformance with the analog signal strength.

## Logic Circuitry

The input signals to the logic section come from the front panel switches, the input stage level detector, GP1B circuitry and the distortion amplifier level detector. The logic circuitry controls the gain of the input stage and distortion amplifier, the db offset generator, location of the decimal points and the function annunciator LEDs.

Diagram 10 shows the logic switching circuitry.

On diagram 11 a presettable up-down counter, U7011, controls the gain of the input stage. In the manual ranges, the preset inputs are enabled by S4171-4. The proper input level range signals are supplied by S4171-1, 2, and 3. In the auto range position, the counter accepts clock inputs from level comparators U5081A and B. These signals pass from U7011 to U3011. They are decoded in U3011, a bcd-to-decimal decoder, to drive the input stage gain control lines.

A dc signal, proportional to the input signal amplitude, appears at pin 4 of U5081A. The bias voltages on pins 5 and 6 of U5081A and B are such that pin 2 of U5081A goes low when the input signal is higher than the range the input stage is presently in. This low appears at pin 10 of U7011 which causes the binary up-down counter to count down. If the input attenuator is in the least sensitive range, a high exists on pin 1 of U7021A. A low then exists on pin 3 of



diodes. In the distortion modes, the decimal points are controlled by the distortion amplifier gain. Gain information from the distortion amplifier appears at 1, 3, 5 and 7. In the dB modes, U3041 is disabled, and Q2063 is turned on by U4071A or U4071B. This illuminates the proper decimal point for all dB displays.

A 4 bit and/or selector (U5061) operating as a multiplexer, selects the control source for the dB offset generator. In the lever mode, the offset is controlled by the sum at the output of U5011. In the distortion modes, U5061 is controlled by the distortion amplifier gain.

### 7 Power Supplies

There are three operating voltages in the AA 5001: + and -15 V dc and +5 V dc. The  $\pm 15$  V supplies the operational amplifiers, linear circuitry and CMOS, while +5 V is used for the logic and display circuitry.

The +5 V dc supply is derived from the +8 V dc supply in the mainframe. A three terminal voltage regulator, U4040, provides +5 V and includes built-in current limiting. Additional overcurrent protection is provided by F4062, R3047 and +5.25 V measured at TP3041.

The +15 V dc supply is regulated from the +26 V dc mainframe supply. The reference voltage, against which the regulator output, divided down by R3043 and R3044 is compared, is supplied by VR3041. Errors between the reference voltage and divided output are amplified by U4041B and Q4050. The mainframe NPN transistor and Q3051 form a Darlingon series-pass transistor. Frequency compensation for stability is provided by R4050 and C4050. Current limiting is accomplished by Q3050 which senses the voltage across R3053. When the current delivered by the +15 V supply exceeds about 500 mA, Q3050 turns on. This shunts base drive current from Q3051 lowering the output voltage. Fuse F4060 provides additional protection.

The -15 V is supplied from the -26 V dc in the mainframe. Amplifier U4041A compares the regulated +15 V supply with the -15 V through R4041 and R4042. Voltage differences are amplified by U4041 and C4051. The mainframe NPN transistor and Q4052 form a Darlingon series-pass transistor. Frequency compensation for stability is provided by R4054 and C4051. Current limiting is accomplished by Q4044 which senses the current through R4053. When the current delivered by the -15 V supply exceeds about 500 mA, Q4053 turns on. This shunts base drive current away from Q4052 and lowers the output voltage of the power supply. Fuse F4061 provides additional protection.

### 7 Interface

This circuitry provides an interface between the microprocessor and the Logic Switches shown on schematic 1C Data on the state of the filter switches as well as the Mode Defeat, Response Drive, IMD Drive and Level Drive input at inputs D0 through D7 on U3010. This integrated circuit is a data selector-multiplexer. The input to be read is selected by lines A, B and C. Data output to the processor is via pin 5.

The filters are controlled via the front panel or the GPIB. The four lines mentioned earlier under this heading are controlled via the processor. This control from the processor passes through U1010, an eight bit addressable latch. The output lines are selected by input lines connected to A, B or C. The status of the output line selected to the latch at pin 13. The output of U1010 can override the front panel filter switches as 20 k $\Omega$  resistors are connected between the switches and the level shifters.

Level shifters U2020 and U1020 provide logic compatible voltage levels for the driven circuitry.

### 13 IM Analyzer

The IMD Analyzer is block diagrammed in Fig. 4-3. In the difference frequency distortion mode (CCIF) the analyzer is a 1.1 kHz 9-pole Butterworth low pass filter. Two poles of this filter are provided by U3081B and associated components. The CCIF signal then passes to the level sensor composed of Q7071, CR5083 and C6071. Depending on the position of jumper P1053 and the amplitude of low frequency components at the anode of CR5083, multiplexer U8051 selects the output from the SMPTE/DIN demodulator at pin 2 or the partially filtered CCIF signal at pin 3. If approximately 1 V or more of low frequency signal is present at the anode of CR5083, Q7071 turns on. If the jumper is in the automatic position, the collector of U7071 goes low. This lowers pins 9, 10, and 11 of U1240 and connects pin 2 to pin 14, the output. In the CCIF mode, there is little power below 1.0 kHz. Under these conditions Q7071 is off, and pin 3 is connected to pin 14 of U8051.

The output of U8051 feeds buffer U6051B. The signals then pass through the remaining 7 poles of the 1.1 kHz low pass filter, comprised of U6051A, U6041A and U6041B, to the distortion amplifier.

In the SMPTE/DIN mode, the input signal passes through 7 poles of a 2 kHz high pass filter to remove the low





tri-state buffer. When pins 19 and 1 are low the logic appearing on the A inputs output to the data bus.

The decimal point illuminated appears as a low on the A1 through A4 inputs of U1044. A5 is not used at present. A6 and A7 is the output from the eight channel decoders, U2045 and U2046 that read the illuminated display segments. U2035A and U2035B serve as level shifters from the eight line display segment decoders. Address decoding is accomplished by U2034.

The data bus connects to U3041, an octal flip-flop. The output from this flip-flop drives open collector inverter U3040. The output from this inverter drives the Logic Switch (schematic 10) and Autorange Control Logic (schematic 11) circuitry.

Various displays data input to the microprocessor via buffer U1031. GPIB communications are controlled by U2022, U2021 and U1020. Bidirectional buffers U2021 and U1020 provide drive capability for U2022, the GPIB interface. The IEEE 488-1978 standard protocol is handled automatically in both talker and listener modes by U2022.

frequency tone. This filter is composed of U3081A, U3061B and U3061A. The signal is full-wave rectified by U3041A and applied to the input of a voltage controlled amplifier U3041B. To maintain a constant signal amplitude of 3.6 V dc, U3031A integrates the difference between this signal and a dc reference voltage. The current through the LED in gain control resistor U2041 maintains the gain of U3041B so that the output is at 3.6 Vdc. The rectifier signal contains the demodulated SMPTE/DIN IM distortion product and passes through a 30 Hz two pole high pass filter comprised of C2021, C2011, R3021 and R3023 to the input of U3031B. This amplifier, along with C5021, C5023, C3031, and C3033 forms the first two poles of the 9-pole 1.1 KHz low pass filter. Pin 7 of U3031B connects to multiplexer U8051. From this point, the signal is processed exactly the same as the CCIF signal.

### GPIB Circuitry

The microprocessor, U4020, is an eight bit parallel processor with a 16 bit address bus. Two 1024 X 4 RAMS, U3034 and U3043, and one 8192 X 8 ROM, U4030, comprise the microprocessor external memory. The GPIB address switch, S3013, connects to the data bus via U3023, a

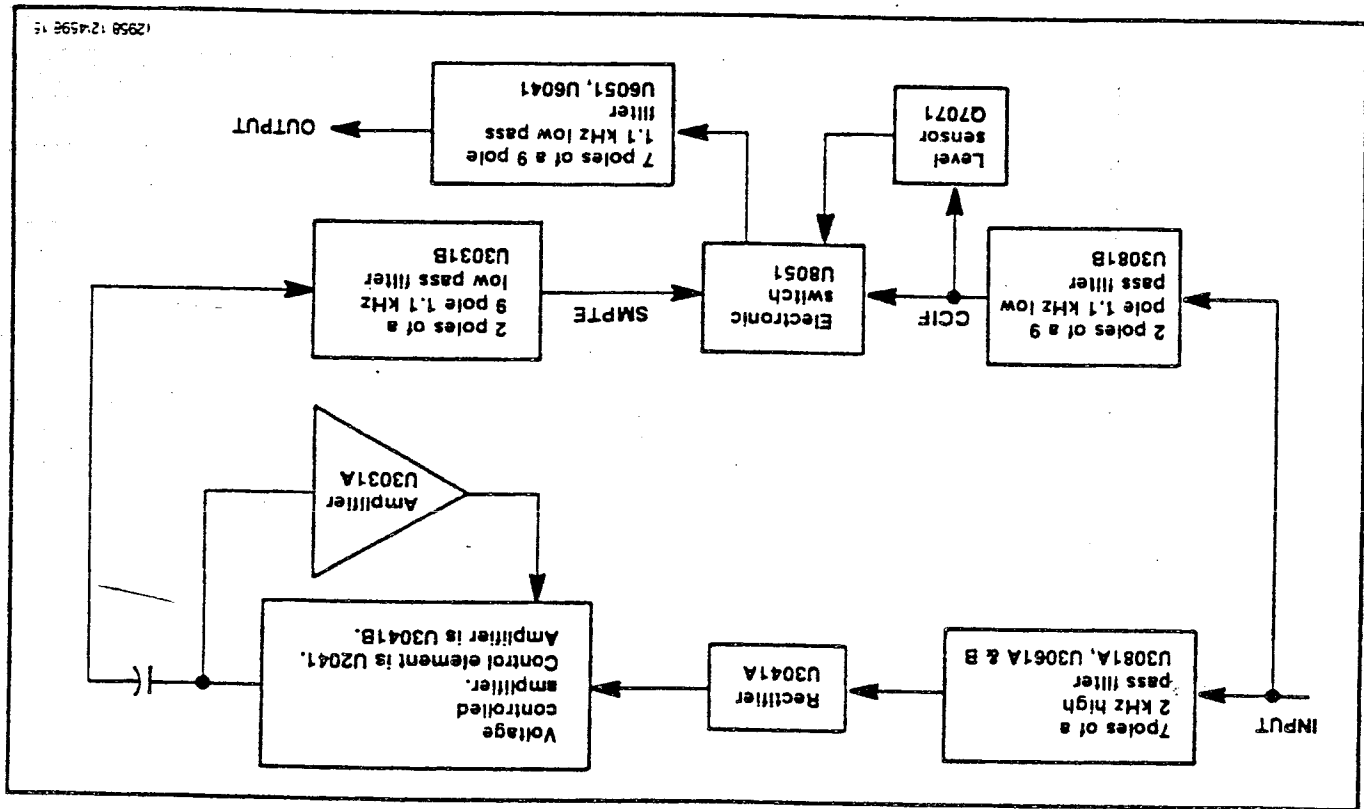


Fig. 4-3. Intermodulation distortion analyzer block diagram.

