TECHNICAL MANUAL

OPERATOR'S, ORGANIZATIONAL, DIRECT SUPPORT, AND GENERAL SUPPORT MAINTENANCE MANUAL

FOR

DISTORTION ANALYZER
TS-4084/G
(NSN 6625-01-217-0054) (EIC: N/A)

This copy is a reprint which includes current pages from Changes 1.

HEADQUARTERS, DEPARTMENT OF THE ARMY
1 April 1987

CHANGE No. 1

Headquarters
Department of the Army
Washington, D.C., 25 August 2005

TECHNICAL MANUAL
OPERATOR'S, ORGANIZATIONAL, DIRECT SUPPORT AND GENERAL SUPPORT MAINTENANCE MANUAL
FOR
DISTORTION ANALYZER TS-4084/G (NSN 6625-01-217-0054) (EIC: N/A)

DISTRIBUTION STATEMENT A – Approved for public release, distribution is unlimited

TM 11-6625-3152-14, dated1 April 1987, is changed as follows:

1. Remove old pages and insert new pages as indicated below. New or changed material is indicated by a vertical bar in the outer margin of the page. Illustration changes are indicated by a pointing hand. New or changed part numbers are indicated by an asterisk (*). Completely revised sections or chapters are indicated by a vertical bar adjacent to the title only.

2. This change implements Army Maintenance Transformation and changes the Maintenance Allocation Chart (MAC) to support Field and Sustainment Maintenance.

Remove Pages	Insert Pages
None	E/(F blank)
i, ii	i, ii
D-1 thu D-7/(D-8 blank)	D-1 thru D-6
DA Forms 2028-2	DA Forms 2028
COVER	COVER

3. File this change sheet in front of the publication for reference purposes.

By Order of the Secretary of the Army:

PETER J. SCHOOMAKER
General, United States Army
Chief of Staff

Official:

SANDRA R. RILEY
Administrative Assistant to the
Secretary of the Army
0519204

Distribution:

To be distributed in accordance with the initial distribution number (IDN) 510238, requirements for TM 11-6625-3152-14.

5 SAFETY STEPS TO FOLLOW IF SOMEONE IS THE VICTIM OF ELECTRICAL SHOCK

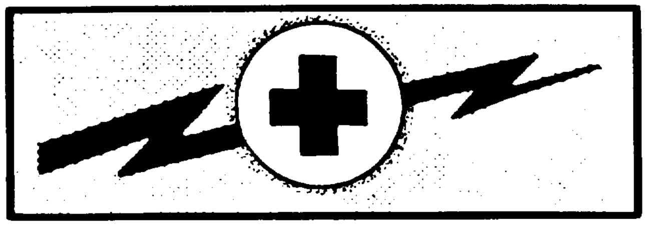
1 DO NOT TRY TO PULL OR GRAB THE INDIVIDUAL

2 IF POSSIBLE, TURN OFF THE ELECTRICAL POWER

3 IF YOU CANNOT TURN OFF THE ELECTRICAL POWER, PULL, PUSH, OR LIFT THE PERSON TO SAFETY USING A DRY WOODEN POLE OR A DRY ROPE OR SOME OTHER INSULATING MATERIAL

4 SEND FOR HELP AS SOON AS POSSIBLE

5 AFTER THE INJURED PERSON IS FREE OF CONTACT WITH THE SOURCE OF ELECTRICAL SHOCK, MOVE THE PERSON A SHORT DISTANCE AWAY AND IMMEDIATELY START ARTIFICIAL RESUSCITATION



W A R N I N G

HIGH VOLTAGE

is used in the operation of this equipment

DEATH ON CONTACT

may result if personnel fail to observe safety precautions

Never work on electronic equipment unless there is another person nearby who is familiar with the operation and hazards of the equipment and who is competent in administering first aid. When technicians are aided by operators, they must be warned about dangerous areas.

Be careful not to contact high-voltage connections of 115-volt ac input connections when installing or operating this equipment.

Whenever the nature of the operation permits. keep one hand away from the equipment to reduce the hazard of current flowing through vital organs of the body

WARNING

Do not be misled by the term "low voltage". Potentials as low as 50 volts may cause death under adverse conditions.

For Artificial Respiration. refer to FM 21-11.

WARNING

A periodic review of safety precautions in TB 385-4, Safety Precautions for Maintenance of Electrical/Electronic Equipment, is recommended. When the equipment is operated with covers removed, DO NOT TOUCH exposed connections or components. MAKE CERTAIN you are not grounded when making connections or adjusting components inside the test instrument.

WARNING

Hot equipment parts can cause serious burns. Before working on equipment that has just been shut down, allow equipment to cool.

INSERT LATEST CHANGED PAGES. DESTROY SUPERSEDED PAGES.

LIST OF EFFECTIVE PAGES

NOTE

ON A CHANGED PAGE, THE PORTION OF THE TEXT AFFECTED BY THE LATEST CHANGE IS INDICATED BY A VERTICAL LINE OR OTHER CHANGE SYMBOL IN THE OUTER MARGIN OF THE PAGE. CHANGES TO ILLUSTRATIONS ARE INDICATED BY A VERTICAL BAR ADJACENT TO THE TITLE. ZERO IN THE "CHANGE NO." COLUMN INDICATES AN ORIGINAL PAGE OR WORK PACKAGE.

Date of issue for original and changed pages are:

Original.. 0 .. 1 April 1987
Change 1 25 Aug 2005

Total number of pages in this publication is 153 consisting of the following:

Page No.	*Change No.
Cover	1
A thru C/(D blank)	0
E/(F blank)	1
i	1
ii thru iv	0
0-0 thru 6-24	0
A-1(A-2 blank)	0
C-1/(C-2 blank)	0
D-1 thru D-6	1
E-1/(E-2 blank)	0
INDEX-1 thru INDEX-6	0
Fig.No. 0-1 thru Fig.No. 6-13	0

* Zero in this column indicates an original page.

TECHNICAL MANUAL
No. 11-6625-3152-14

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., 01 April 1987

OPERATOR'S, ORGANIZATIONAL, DIRECT SUPPORT AND GENERAL SUPPORT MAINTENANCE MANUAL FOR

DISTORTION ANALYZER TS-4084/G (NSN 6625-01-217-0054) (EIC N/A)

REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS

You can help improve this manual. If you find any mistakes or if you know of a way to improve the procedures, please let us know. Mail your letter or DA Form 2028 (Recommended Changes to Publications and Blank Forms) directly to: Commander, U. S. Army Aviation and Missile Command, AMSAM-MMC-MA-NP, Redstone Arsenal, AL 35898-5000. A reply will be furnished to you. You may also provide DA Form 2028 information to AMCOM via email, fax or the World Wide Web. Our fax number is: DSN 788-6546 or Commercial 256-842-6546. Our email address is: 2028@redstone.army.mil. Instructions for sending an electronic 2028 may be found at the back of this manual immediately preceding the hardcopy 2028. For the World Wide Web use: https://amcom2028.redstone.army.mil.

DISTRIBUTION STATEMENT A – Approved for Public Release; Distribution is Unlimited.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

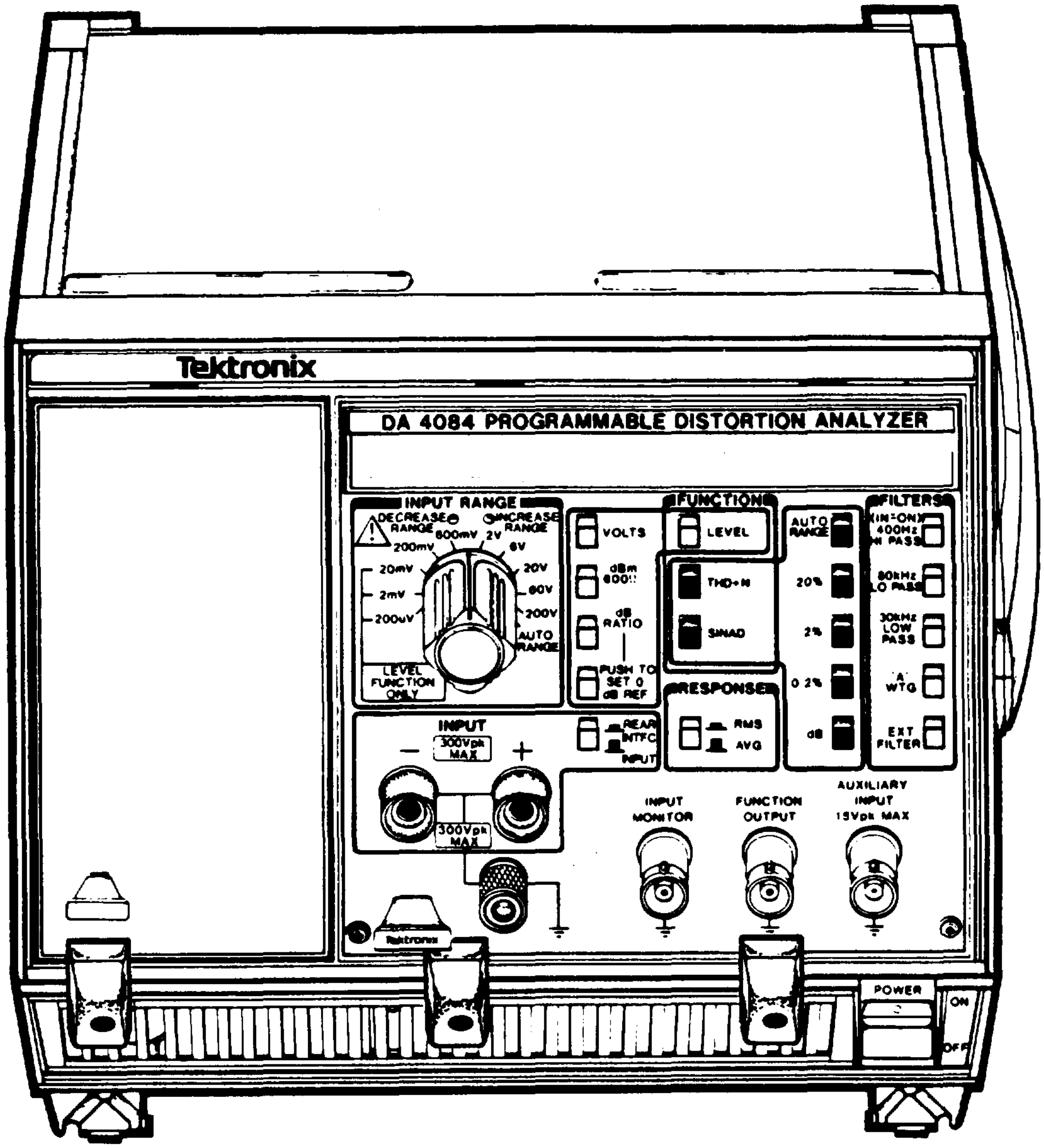


Fig. O-1. TS-4084/G Programmable Distortion Analyzer

SECTION 0

INSTRUCTIONS

0-1. SCOPE.

This manual contains instructions for the operation and maintenance of Programmable Distortion Analyzer, Tektronix Modal DA 4084. Throughout this manual Programmable Distortion Analyzer, Model DA 4084 is referred to as either the Instrument or TS-4084/G.

0-2. CONSOLIDATED INDEX OF ARMY PUBLICATIONS AND BLANK FORMS.

Refer to the latest issue of DA PAM 310-1 to determine whether there are new additions, changes, or additional publications pertaining to this equipment.

0-3. MAINTENANCE FORMS, RECORDS, AND REPORTS.

a. Reports of Maintenance and Unsatisfactory Equip ment. Department of the Army forms and procedures used for equipment maintenance will be those prescribed by DA PAM 738-750 as contained in Maintenance Management Update.

b. Report of Packaging and Handling Deficiencies. Fill out and forward SF 364 Report of Discrepancy (ROD) as prescribed in AR 735-11-2/DLAR 4140.55/NAVMATINST 4355.73B/AFR 400-54/MC0 4430.3H.

c. Discrepancy in Shipment Report (DISREP) (SF 361). Fill out and forward Discrepancy in Shipment Report (DISREP) (SF 361) as prescribed in AR 55-38/NAVSUPINST 4610.33C/AFR 75-18/MCO P4610.19D/DLAR 4500.15.

0-4. REPORTING EQUIPMENT IMPROVEMENT RECOMMENDATIONS (EIR).

If your Distortion Analyzer needs improvement, let us, know. Send us an EIR. You, the user, are the only one who can tell us what you don't like about the design. Put it on an SF 368 (Quality Deficiency Report). Mail it to Commander, US Army Communications-Electronics Command and Fort Monmouth, ATTN: AMSEL-PA-MA-D, Fort Monmouth, New Jersey 07703-5000. We'll send you a reply.

0-5. ADMINISTRATIVE STORAGE.

Administrative storage of equipment issued to and used by Army activities will have preventative maintenance performed in accordance with PMCS charts before storing. When removing the equipment from administrative storage the PMCS should be performed to assure operational readiness.

0-6. DESTRUCTION OF ARMY ELECTRONICS MATERIEL.

Destruction of Army electronics materiel to prevent enemy use shall be in accordance with TM 750-244-2.

Section 1

SPECIFICATION

Instrument Desciption

The TS-4084/G is a fully automatic programmable distortion analyzer in a dedicated power supply. This instrument offers true rms voltage measurement Capabilities. volts, dBm or dB ratio display modes are provided. The TS-4084/G features a 0 dB set reference memory in the dB ratio mode. A 3 1/2 digit readout and an analog display for nulling and peaking indications are included.

Level setting, tuning and nulling are fully autornatic. Input level range and distortion measurement range selections are fully automatic or manual. A selection of predetection filters, functional in all modes, is included. These filters provide conditioning to minimize the effects of extraneous signals. A position for an auxiliary fitter is also provided.

CAUTION

This power supply is not compatible with Tektronix TM 500 or TM 5000 plug-ins.

Performance Conditions

The electrical characteristics in this specification are valid only if the TS-4084/G has been adjusted at an ambient temperature between + 20°C and + 30°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.

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 this manual.

Table 1-1
ELECTRICAL CHARACTERISTICS

Characteristics	Performance Requirements	Supplemental Information
INPUT (ALL FUNCTIONS)		
Impedance	100k Ω ±2%, each side to ground	Full differential. Each side ac coupled through 1 µF and shunted to ground by approximately equal to 200 pF. Dual banana jack connectors at 0.750 inch spacing with ground connector additionally provided.
Input ranges	200 µ V to 200 V in10 steps	2-6 sequence from 200 to µV 200 V Range selection is manual or automatic. Autoranging 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 on all ranges. For linear response peak input voltage must not exceed 3 times INPUT LEVEL RANGE setting.
Common mode rejection (inputs shorted)	≥50 dB at 50 or 60 Hz decreasing to 40 dB at 800 Hz for common mode signals up to one-half of selected input range or 50 mV, whichever is greater.	Typically ≥40 dB to 300 kHz.
LEVEL FUNCTION		
Modes		Volts, dBm (600 Ω), 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.

Table 1-1 (cont.)
ELECTRICAL CHARACTERISTICS

Characteristics	Performance Requirement		Supplemental Information
Accuracy (level ranging indicators extinguished)	volts	dB Modes	
20 Hz to 20 kHz	VVithin ± 2% + 1 count	± 0.3 dB	
10 Hz to 20Hz 20 kHz to 100 kHz	Wtihin ± 4% +2 counts	±0.5 dB	
Bandwidth (no filters selected)	At least 300 kHz		
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.		
TOTAL HARMONIC DISTORTION PLUS NOISE AND SINAD FUNCTION			
Fundamental frequency range	10 Hz to 100 kHz		Fully automatic tuning and nulling. For proper tuning THD+N ≤ 10%. After initial tuning THD+ N can degrade to 50% without loss of lock for SINAD testing. Typioal nulling time is leas than 6 seoonds above 20 Hz.
Minimum input level	100 mV (-17.8dBm)		
Distortion ranges			Auto range, 20%, 2%, 0.2%, and dB. dB is internally autoranging with single effective display range. Auto range allows measurements above 20?/..
Accuracy (THD ≥ 50% and readings ≥ 4% of selected distortion range).			Accuracy is limited by residual THD+N and filter selection

Table 1-1 (cont.)
ELECTRICAL CHARACTERISTICS

Characteristics	Performance Requirement	Supplemental Information
Fundamental Frequency		
10 Hz to 20 kHz	±1 dB (0.1%–50%)	
20 kHz to 50 kHz	±2 dB (0.1%–50%)	
50 kHz to 100 kHz	+3 dB, –4 dB (0.1%–50%)	
Residual THD+N (Vin ≥ 250 mv,all disortion, noise, and nulling error souces combined, T ≤ 40° C)	Measured with a low-distortion sinewave oscillator.	
20 Hz to 20 kHz With 80 kHz noise limiting filter	≤ 0.005% (–66 dB)	
10 Hz to 20 Hz 20 kHz to 100 kHz	≤ 0.015% (–76.5 dB)	
Typical fundamental rejection		At least 10 dB below specified residual THD+N or the actual signal THD, whichever is greater.
FILTERS		
400 Hz high pass	–3 dB at 400 Hz ±5%; at least –40 dB rejection at 60 Hz.	Three pole Butterworth response
80 kHz bw pass	–3dB at 60 kHz ±5%	Three pole Butterworth response
30 kHz low Pass	–3dB at 30 kHz ±5%	Three pole Butterworth response

Table 1-1 (cont.)
ELECTRICAL CHARACTERISTICS

Characteristics	Performance Requirement	Supplemental Information
FRONT PANEL SIGNALS		
INPUT MONITOR		
Vin ≥ 50 mV	1 V rms ±10%	10 Hz to 100 kHz Constant amplitude (average response) version of differential input signal. THD is typically ≤0.0010% (– 100 dB) from 20 Hz to 20 kHz.
Vin ≤ 50 mV		Approximately 20 times input signal
Impedance	1 kΩ ±50%	
FUNCTION OUTPUT		
Signal	1 V ±3% for 1000 count volts or % display	Selected and filtered ac signal actually measured
Impedance	600 Ω ±5%	
AUXILIARY INPUT		
Sensitivity	1 V ±3% for 1000 count volts or % display	Loop through accuracy from FUNCTION OUTPUT is ±3%.
Maximum Input Voltage		15 V peak, 6 V peak for linear response
Impedance	100 kΩ ±5%	Ac coupled
DISTORTION ANALYZER REAR INTERFACE SIGNALS		
Rear interface input		Pins 286 (+), 28A (–), 276 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.
Input monitor		Pins 24A and 23A (grid) same as front panel INPUT MONITOR

Table 1-1 (cont.)
ELECTRICAL CHARACTERISTICS

Characteristics	Performance Requirement	Supplemental Information
Function output		Pins 23B and 24B (grid) same as front panel FUNCTION OUTPUT.
Auxiliary input		Pins 256 and 266 (grid) 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 (grid). Dc output of the selected ac to dc converter. 1 V ±5% for 1000 count display with 500 Ω ±5% source resistance.
dB converter output		Pins 19B and 206 (grid). Dc output of the logarithmic dB converter. 10 mV ±5% equals 1 dB of display with 1 k Ω ±5% source resistance. Changes in level or distortion range will cause brief ac transients.
DETECTORS AND DISPLAYS		
Detectors (Response)		
RMS		True rms detection
AVG		Average detection, rms calibrated for sinewaves. Typically reads 1 to 2 dB lower than true rms detection for noise, and THD + N measurements.
Displays		
Digital		3 1/2 digit, 2000 oount LED. Overrange indication is 1, blank, blank, blank.
Analog bar graph		10 segment LED intensity modulated bar graph display of digital readout. Segments are Iogarithmioally activated with approximately 2.5 dB/segment.

Table 1-1 (cont.)
ELECTRICAL CHARACTERISTICS

Characteristics	Performance Requirement	Supplemental Information
SOURCE POWER REQUIREMENTS		
Voltage Ranges	Selectable 100 V, 120 V, 220 V, and 240 V nominal line ±10%	
Line Frequency	48 Hz to 440 HZ	
Fuse Data		
100 V, 120 V ranges	3AG, .6A, 250 V, slow blow	
220 V, 240 V ranges	3 AG, .3A, 250 V, medium blow	
Power consumption	Approximately equal to 36 watts	
MISCELLANEOUS		
Internal Power Supplies (Al 5)		
+15		Nominally +15.1 V ±30%
–15		Nominally –15.1 v ±5%
+5		Nominally +5.25 V ±5%
Fuse Data, Internal Power Supply (A15)		
F4060		3AG, 1 A, 250 V, fast blow
F4061		3AG, 1 A, 250 V, fast blow
F4062		3AG, 1.5 A, 250 V, fast blow
Warm-up time		20 minutes; 60 minutes after storage in high humidity environment.

Table 1-2
ENVIRONMENTAL CHARACTERISTICS

Characteristics	Description	
Temperature		
Operating	0° C to +50°C	
Nonoperating	–40° C to +75° C	
Humidity	95% RH, 0° C to 30° C 75% RH, to 40° C 45% RH, to 50° C	Meets MIL-T-28800C, class 5.

Table 1-3
PHYSICAL CHARACTERISTICS

Characteristics	Description
Net Weight	Approximately equal to 16 Ibs. (7.2 kg)
Overall Dimensions	Height 193.8 mm (7.83 inches) Width 229.84 mm (9.049 inches) Length 476 mm (18.74 inches)

Section 2
OPERATING INSTRUCTIONS

DISTORTION ANALYZER

Preparation For Use

The TS-4084/G is calibrated and ready for use when received. The TS-4084/G is a combination power supply and audio distortion analyzer. The distortion analyzer module is installed in the two compartments on the far right of the power supply and a blank cover is installed in the left compartment.

NOTE

The power supply is not compatible with other Tektronix TM 500 or TM 5000 plugins.

Check the rear panel line voltage indicator to determine if the factory settings are compatible with the available line voltage and frequency. Refer a qualified service technician to "Preparation For Use" in the Maintenance section of this manual if a change is needed.

Push the power switch on the TS-4084/G. One or more characters in the LED display should now be visible.

NOTE

The TS-4084/G 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.

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

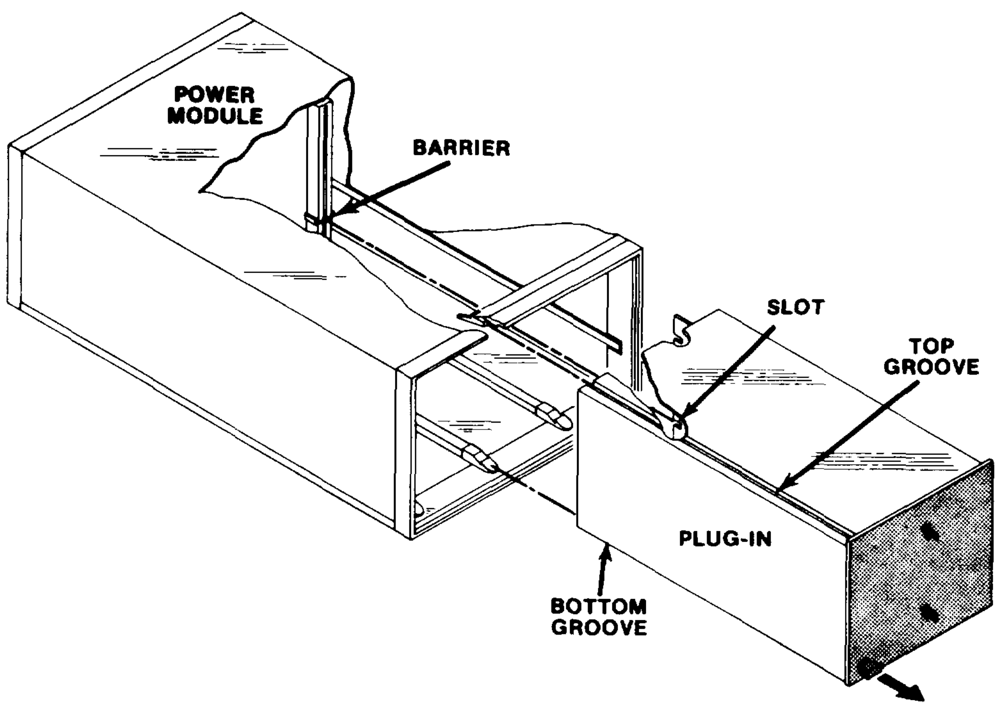


Fig. 2-1. Installation and removal.

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 275 pounds per square inch.

Controls, Connectors, and Indicators

All controls, connectors and indicators required for operation of the TS-4084/G are located on the front penal. 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 TS-4084/G 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 a flashing light indites 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**
Differential input terminal. Positive going input signal provides positive going output signal at INPUT MONITOR.

(5) **INPUT**
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. 0dB reference is 0.7746V 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 RATIO 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. Both are rms calibrated for sinewaves.

(14) **THD+N**
Button in selects total harmonic distortion function.

(15) **SINAD** button is a sensitivity measurement computed from the ratio of signal plus noise and distortion to noise and distortion.

(16) **AUTO RANGE**
Button in selects automatic distortion range selection (0.2% to 100% full scale). (The TS-4084/G goes to AUTORANGE when in a remote state.)

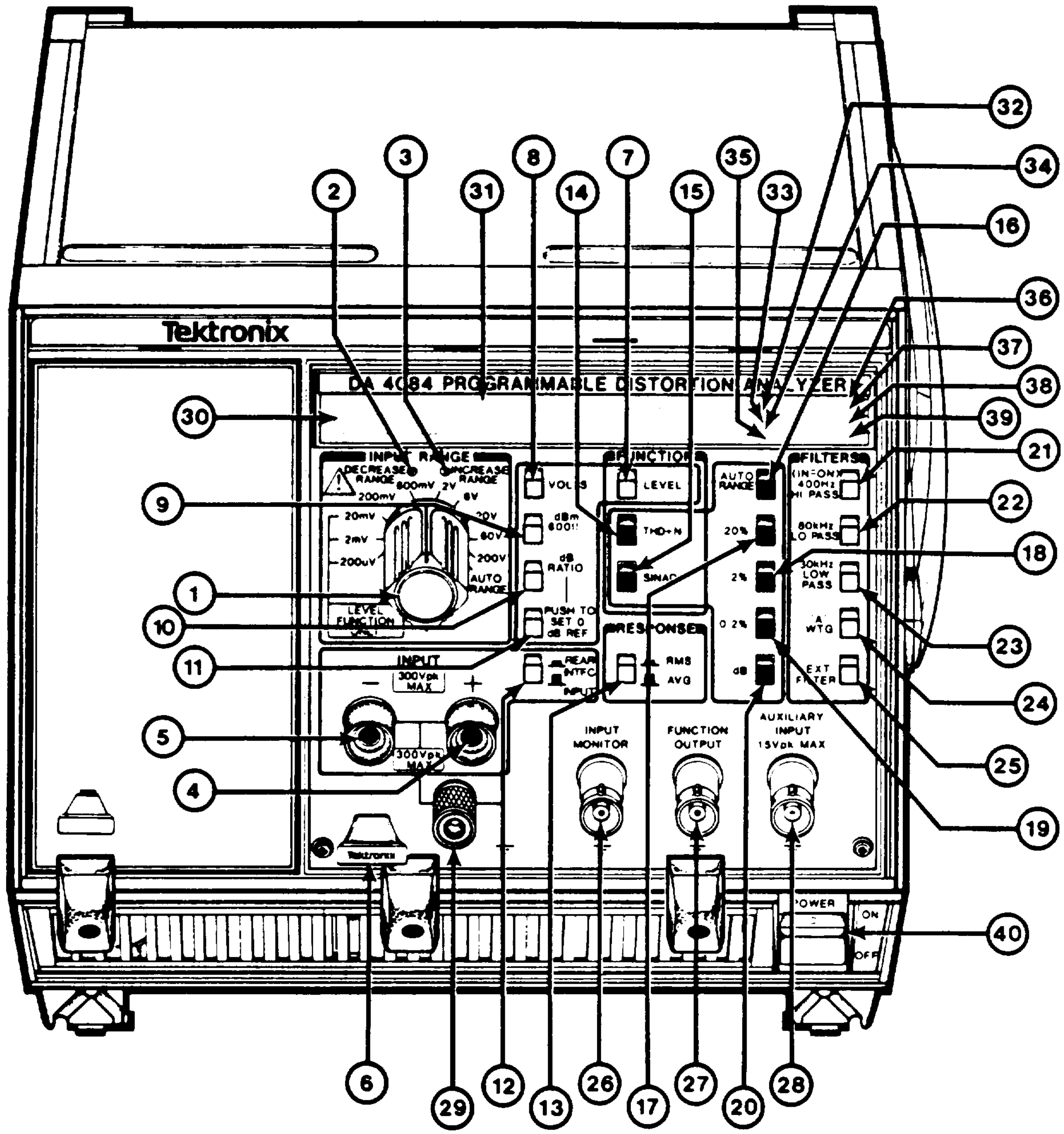
(17) **20%**
Button in selects full scale distortion readout of 20% with 0.01% resolution.

(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 0.20% 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.



CE0JR002

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

80 kHz LO PASS
Button in connects filter before detector circuit in all functions

30 kHz LO PASS
Button in connects filter before detector circuit in all functions.

"A" WEIGHTING
Button in connects filter before detector circuit in all functions.

EXT FILTER
Button in shows connection of external filter between FUNCTION OUTPUT and AUXILIARY INPUT in all functions.

INPUT MONITOR
Provides a constant amplitude version of the differential input signal.

FUNCTION OUTPUT
Provides a scaled and filtered output signal of the function selected.

AUXILLIARY INPUT
Provides input to the detector circuit when the EXT FILTER button is pressed.

Ground
Provides front panel chassis ground connection.

LED Bar Graph
Provides approximate analog display of the digital display for nulling and peaking. Each segment represents approximately 2.5 dB.

Digital Display
3 1/2 digits. Overrange indication is a blanked display with the numeral L in the most significant digit position.

V
Illuminated when display units are volts.

mV
Illuminated when display units are millivolts.

μV
Illuminated when display units are microvolt.

%
Illuminated when display units are percent.

REM
Illuminated when the TS-4084/G is in the remote state or the remote with lockout state.

UNLK
Illuminated when the TS4084/G is not locked onto the fundamental in the THD + N or SINAD functions.

dBm
Illuminated when display units are dBm.

dB
Illuminated when display units are dB.

Power Switch

Instrument Connections

To make connections to the TS-4084/G, 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.

CAUTION

Maximum frotnt 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 TS-4084/G 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 instructions. Shielded, twisted pair offers maximum hum and radio frequency interference rejection. Cable shielding, if used, should be grounded only at the TS-4084/G 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.

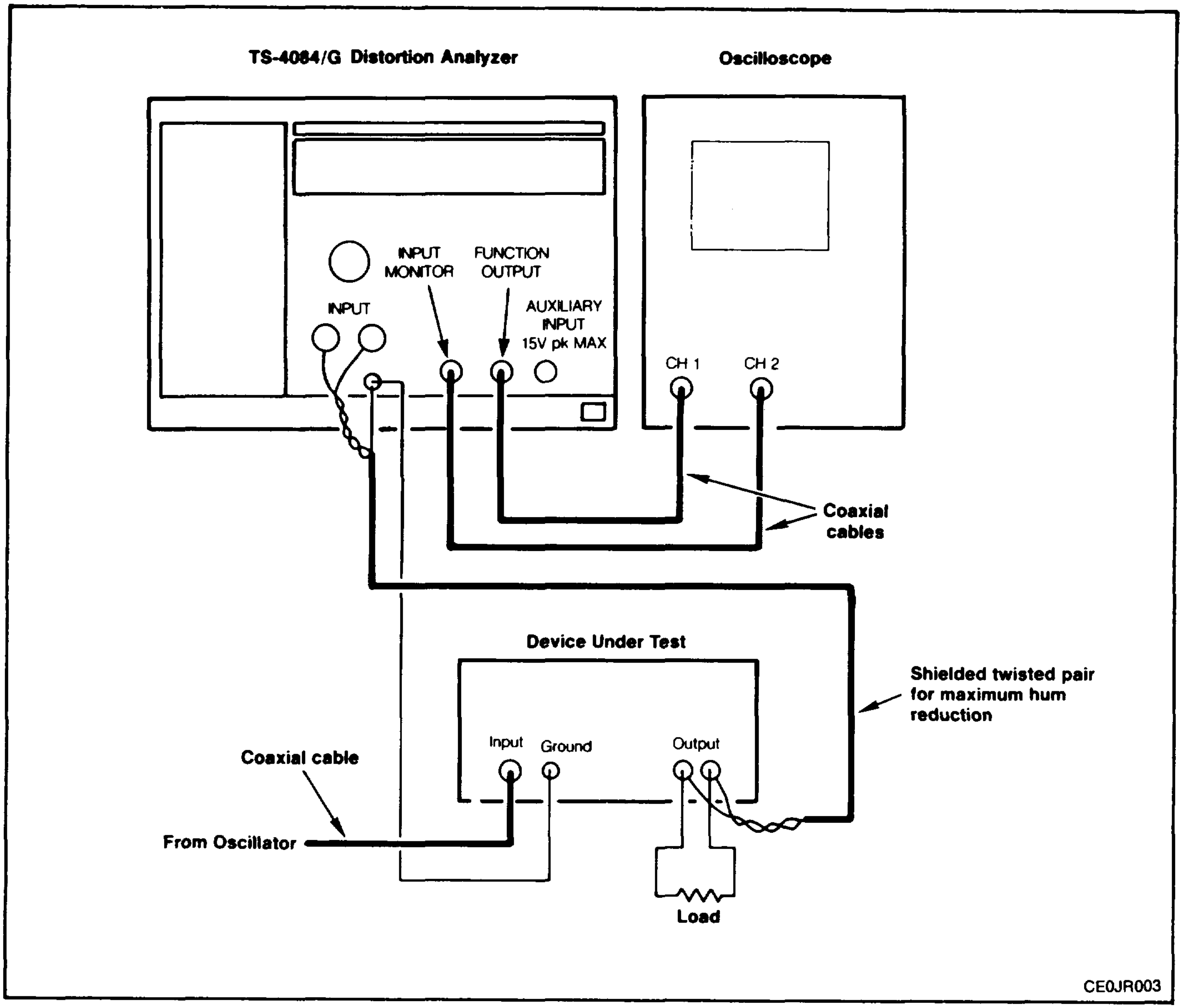


Fig. 2-3. Typical connections for distortion measurements. See text.

The illustration shows an optional osciiloscope 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 THD + N function.

Level Measurements

In the LEVEL function the TS-4084/G 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 responding, depending on the position of the RESPONSE pushbutton.

Press the FUNCTION LEVEL pushbutton. The top three buttons to the left of the FUNCTION pushbuttons select readout units as VOLTS, dBm 600 Ω, or dB RATIO. For example, to measure voltage press the VOLTS pushbutton.

If the INCREASE RANGE LED is illuminated, adjust the LEVEL RANGE control to the higher ranges until the LED goes out. (With the TS-4064/G 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 RANGE switch is placed in the AUTO RANGE position, the input level is adjusted automatically. The LED's (V, mV or μV) automatically illuminate showing the proper display units. Notice that the three most sensitive ranges on the INPUT RANGE control operate in the LEVEL FUNCTION only.

When the dBm 600 Ω pushbutton is pressed, the LED behind dBm on the display indicates the display units, The reference level for this measurement, 0 dBm, is 0.7746V corresponding to 1 mW dissipated in 600 Ω. The INPUT RANGE switch operates as previously described.

The dB RATIO mode permits direct amplitude ratio measurements of two input signals. When the dB RATIO pushbutton is pressed, the LED behind the dB nomenclature on the display illuminates. To use this feature, press the dB 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 is changed, the display reads the dB ratio of the input signal to the reference signal ampltudes.

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 TS-4084/G input to the input of the device under test. Press the PUSH TO SET 0 dB REF pushbutton. Then connect the input of the TS-4084/G 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 TS-4084/G 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.

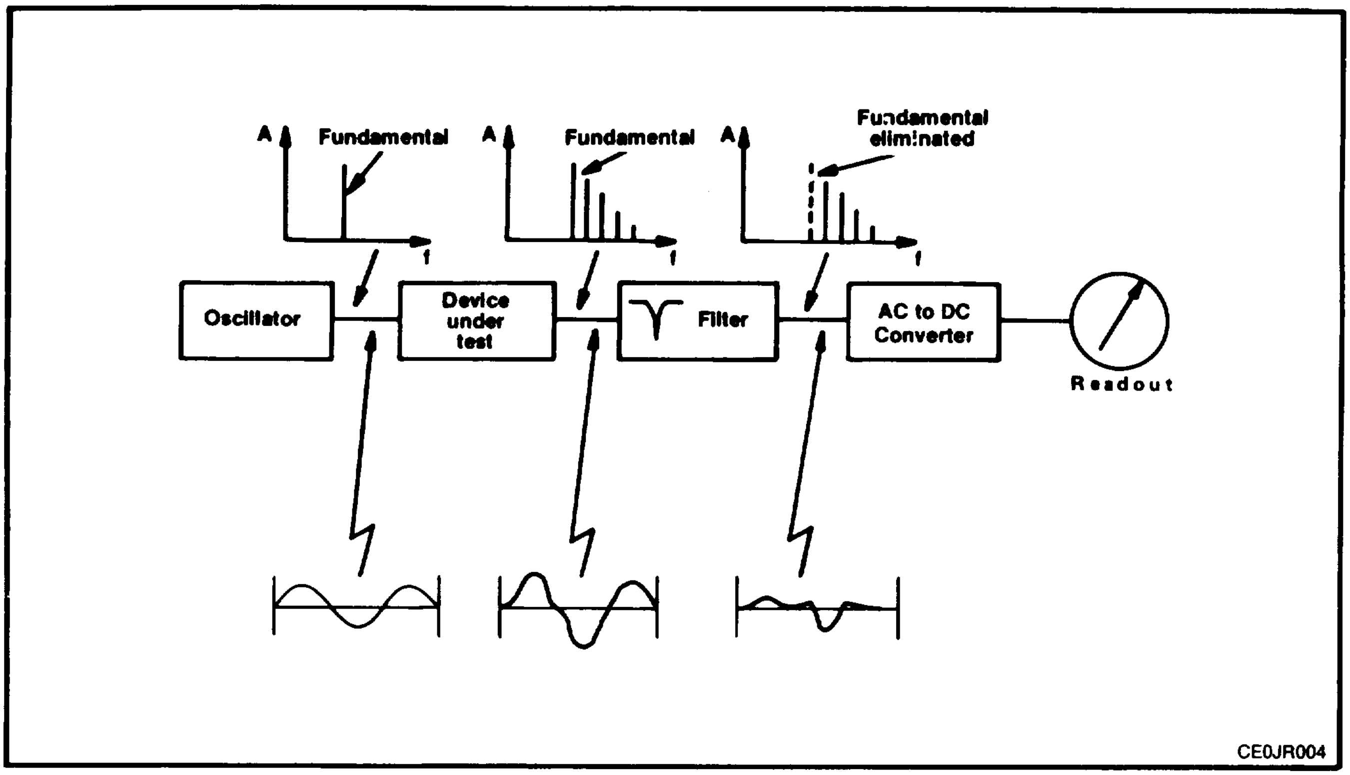


Fig. 2-4. Block diagram of a basic harmonic distortion analyzer.

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.

A total harmonic distortion measurement inevitably includes effects from noise or hum. The term THD + N or SINAD has been recommended to distinguish distortion measurements made with a distortion analyzer from those made with a spectrum analyzer. A spectrum analyzer allows direct measurement of each harmonic. However, it is relatively complex, time consuming, and requires interpretation of a graphic display.

Distortion analyzers can quantify the nonlinearity of a device or system. The transfer (input vs output) characteristic of a typical device is shown in Fig. 2-5. Ideally this is a

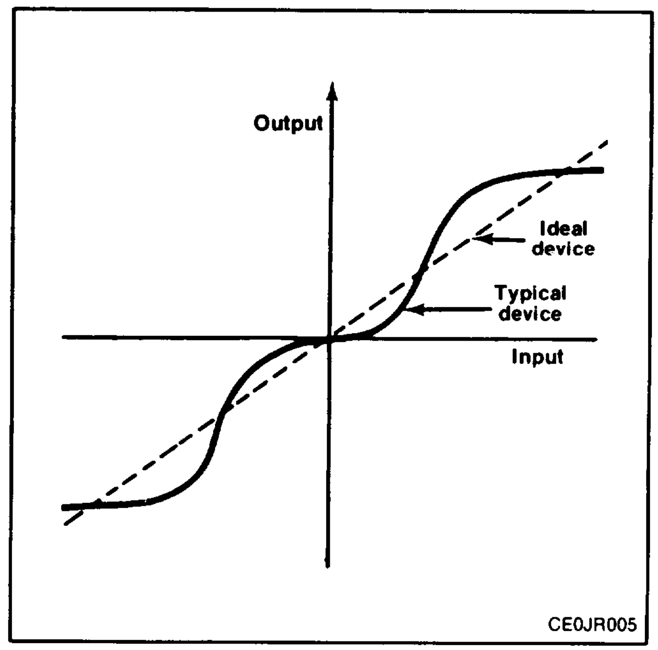


Fig. 2-5. Transfer characteristics of an audio device.

[1]IHF-A0202 1978, Standard Methods of Measurement for Audio Amplifiers, The Institute of High Fidelity, Inc., 489 Fifth Avenue, New York, N.Y. 10017.

straight line. A change in the input produces a proportional change in the output. Since the actual transfer characteristic is nonlinear, a distorted version of the input waveshape appears at the output. The output waveform is the projection of the input sine wave on the device transfer characteristic as shown in Fig. 2-6. The output waveform is no longer sinusoidal, due to the nonlinearity of the transfer characteristic. Using Fourier series it can be shown that the output waveform consists of the original input sine wave, plus sine waves at integer multiples of the input frequency. These harmonics represent nonlinearity in the device under test. Their amplitudes are related to the degree of nonlinearity.

Distortion Measurement Procedure

All of the controls found on a traditional distortion analyzer are automated on the TS4084/G. it is only necessary to set the INPUT RANGE and distortion range switches to AUTO RANGE, press the THD+N or SINAD and wait briefly for a reading.

Minimum input signal amplitude for valid distortion measurements is 100 mV. To provide greater flexibility the instrument may be manually operated as described in the following paragraphs.

Adjustment of the input range control is the same as for level measurements. Setting the INPUT RANGE control to the correct scale ensures that the input is within the 10 to 12 dB range of the internal auto set-level circuitry. The range LED's must be extinguished to make readings to specified accuracy. The 200 µV, 2 mV and 20 mV ranges do not operate in the distortion function and a flashing Decrease Range LED indicates insufficient input signal level for distortion measurements.

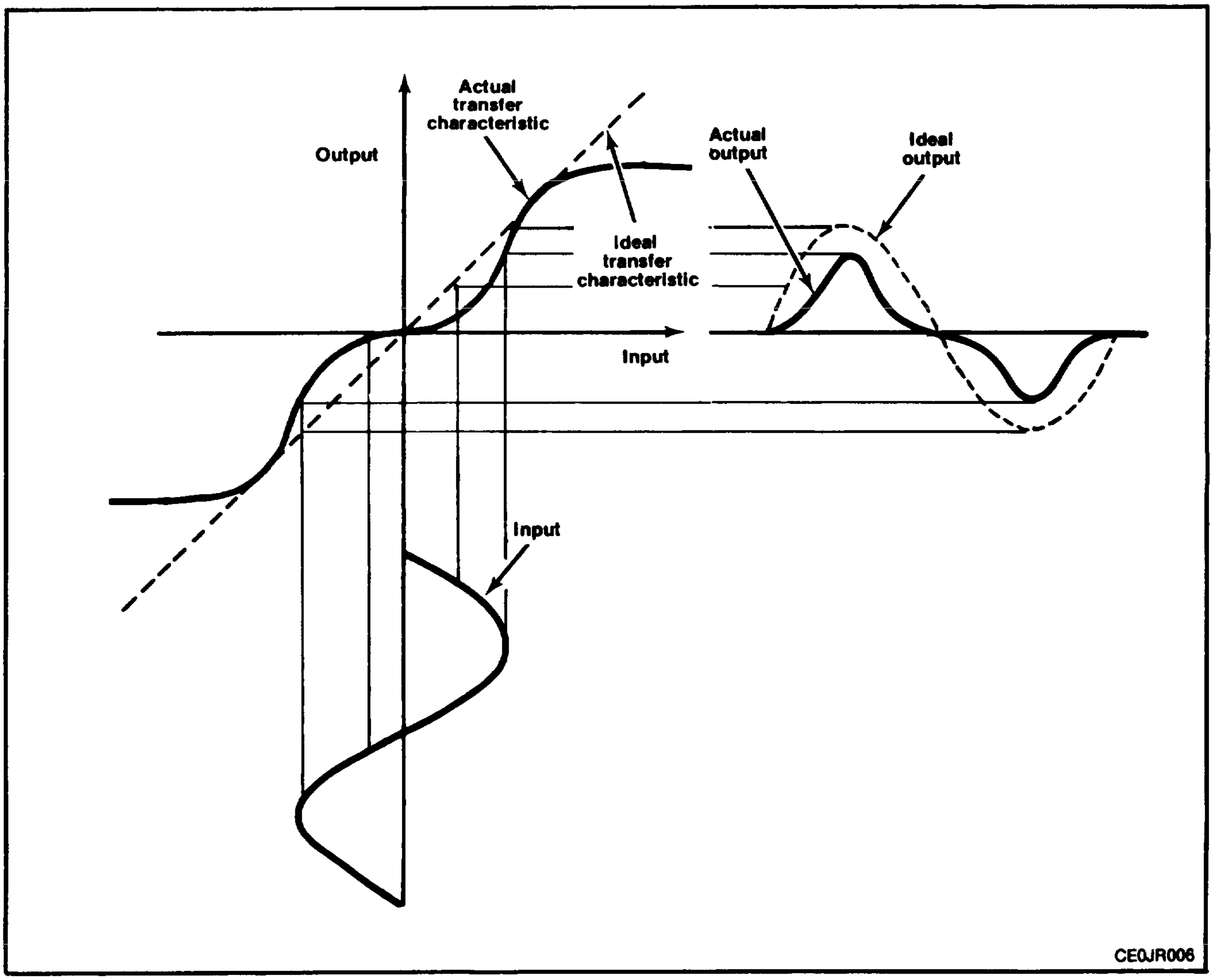


Fig. 2-6. THD test of transfer characteristics.

To manually select a distortion range, press the THD + N button and the desired range button. Selection of AUTO RANGE causes the instrument to autorange the distortion readout. (With the TS4084/G in a remote state, the distortion range automatically goes to the AUTORANGE position, irrespective of the actual switch positions.) The remaining range pushbuttons cause the instrument to stay in these ranges without autoranging. This may reduce the measurement time slightly if the approximate reading is already known. This is useful in production line testing or in the testing of low distortion equipment. The dB display is effectively a single range; however, internal instrument operation is identical to AUTO RANGE.

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 residual wideband noise in the measurement may be reduced by activating the 80 kHz LO PASS filter, If hum (line related components) is interfering with the measurement, it 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 TS-4084/G 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[2] testing) the internal circuitry will remain locked to noise levels of approximately 50%, after it is initially given a clean signal. To perform a SINAD test, the receiver under testis first given a high level) modulated rf input. The TS-4084/G will lock onto the audio signal at the demodulated output. The rf level feeding the receiver is then reduced until a – 12 dB (25%) THD + N reading is obtained on the TS-4084/G and becomes a measure of the receiver's sensitivity.

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. 2-7 for response curves of the various filters. The 400 Hz, 80 kHz and 30 kHz filters are all 3-pole (18 dB per octave rolloff) Butterworth alignment. 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.

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 overrange or by pressing the AUTO RANGE pushbutton.

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 TS-4084/G 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 measuring levels at frequencies less than 1 kHz, nor when measuring intermodulation distortion.

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, it allows measurement of harmonics up to the fourth order. 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 30 kHz LO PASS or WEIGHTING filters are recommended as they correlate better with the perceived noise level. When the 30 kHz LO PASS filter is used, the 80 kHz filter is disabled.

[2]Defined in Electronic Industries Association Standard No. RS204A, July 1972, Electronic industries Association, Engineering Department, 2001 Eye St. N. W., Washington, D.C. 20006.

Fig. 2-7. Response curves for TS-4084/G filters.

The “A" weighting filter is used when measuring the subjective noisiness 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[3] standards for class 1 sound level maters.

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 TS-4084/G provides two display forms for manual measurements. The digital readout displays the selected function with units. Overrange indication blanks all digits and displays a 1 in the moat significant digit slot.

[3]International Electrotechnk81 Commission, Publication 179, second edition, Precision Sound Level Meters, 1973, Central Office of EIC (sales department), 1, rue de Varembe', 1211 Geneva 20 Switzerland.

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.

Monitoring

The interface capabilities of the TS-4084/G may aid considerably in the interpretation of measurements.

The INPUT MONITOR connector provides a fixed amplitude version (approximately equal to 1 V rrns) 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 amplified 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 INPUT RANGE switch, and is given in Table 2-1. When the TS-4084/G 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 TS-4084/G.

One interesting use of the Function Output and Input Monitor signals is to investigate the non-linearities of the 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. 2-8, 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 y of the oscilloscope.

Table 2-1
GAINS FROM INPUT TERMINALS TO FUNCTION OUTPUT

INPUT 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

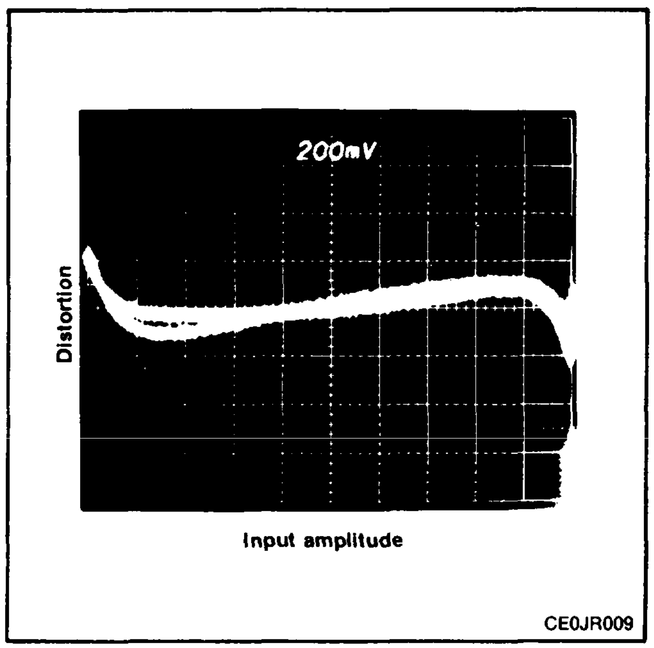


Fig. 2-8. Oscilloscope display of deviation from linearity.

POWER SUPPLY

Power Source Requirements

WARNING

__Ac Power Source and Connection.__ This instrument operates from a single-phase power source. It has a three-wire power cord and two-pole, three-terminal groundingtype plug. The voltage to ground (earth) from either pole of the power souroe must not exceed the maximum rated operating voltage, 250 volts. Before making connection to the power source, determine that the Instrument is adjusted to match the vo/tage of the power source, and has a suitable two-pole, three-terminal grounding-type plug. Refer any changes to qualified service personnel.

__Grounding.__ This instrument is safety class I eqfipment (IEC designation). All accessible conductive parts are directly connected through the grounding conductor of the power cord to the grounding contact of the power plug.

The power input plug must only be inserted in a mating receptacle with a grounding contact. Do not defeat the grounding connection. Any interruption of the grounding connection can create an electric shock hazard.

For electric shock protection, the grounding connection must be made before making connection to the instrument's input or output terminals.

Fuse Replacement

Remove the line cord and slide open the plastic cover door on the fuse box. Pull the lever labelled FUSE PULL out to the side to eject the fuse. Replace the fuse with the proper type as shown on the rear panel label.

Cabling

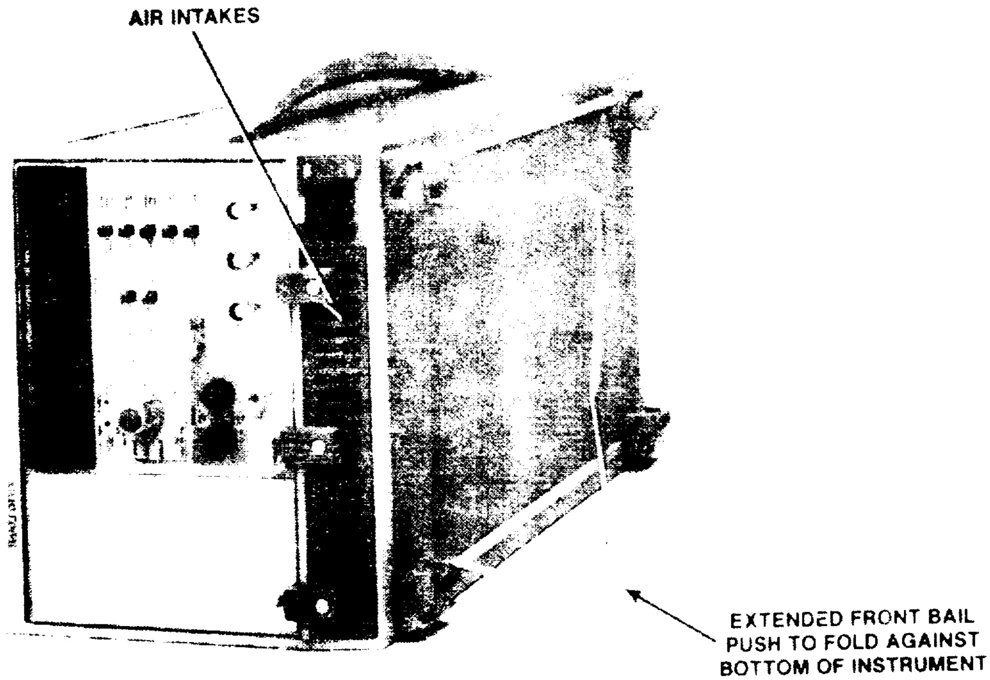
CAUTION

Remove power cord before attempting cable installation.

For convenience, cabling from the front of the power supply to the rear panel may be run through the air intake and cable raceway. To install this cabling first remove the access panel on the rear of the power supply. Next remove the two bottom panel retainer screws and the bottom panel retainers. Slide the bottom panel out from the rear of the instrument. Pass the cable through the front air intake, across the bottom of the plug-in support rails and out the access panel. Replace the power supply bottom cover.

Table Top Use

The power supply may be operated with the front raised. To raise the front of the instrument extend the front bail as shown in Fig. 2-9.



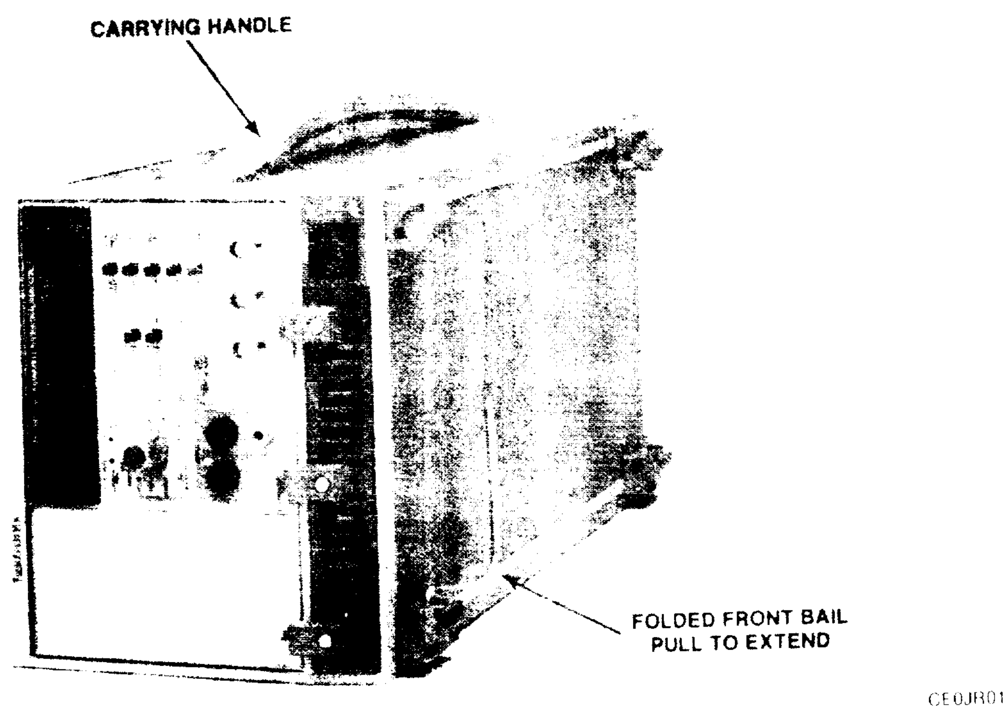


Fig. 2-9. TS-4084/G bottom view.

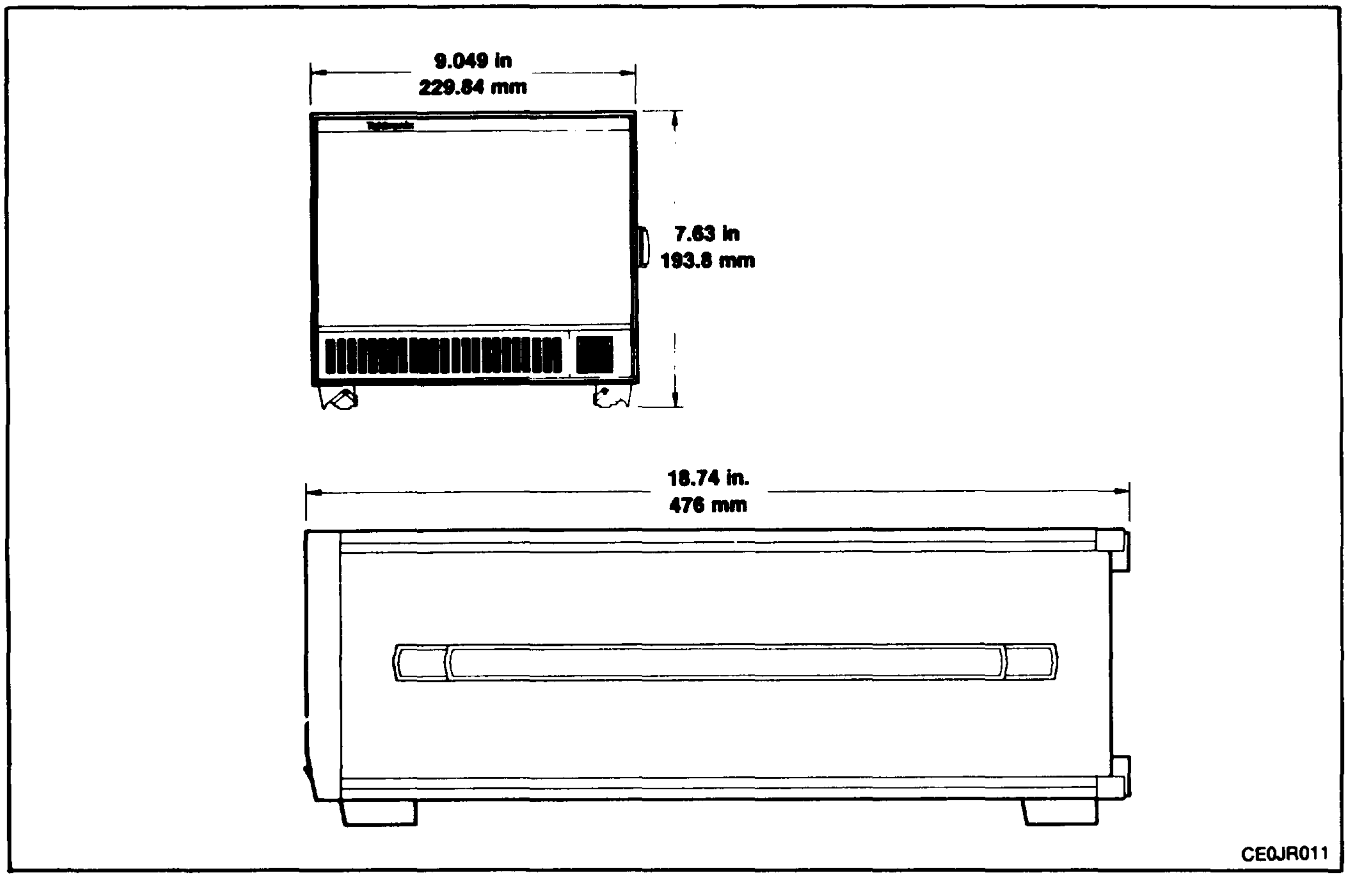


Fig. 2-10. TS-4084/G, overall dimensions.

Section 3
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 TS4084/G operation. A detailed circuit description follows.

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 amplified unity gain.

The input signal, from the front panel connections or the rear interface input (selected by front panel switch S6181) enters the input amplified through P4070/J4070. Each input is ac coupled through C5070 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 TS-4084/G 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 CR 4072 through CR 4075. When the post attenuator voltage on any scale exceeds about ± 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 (age) 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 TS-4084/G 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-J1 060, 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 0 dB, +10 dB or +20 dB (pins 6, 7 or 8) is activated, K2052 activates directly or by Q1070 and U10506. in 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

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 Vat. 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 cells resistance decreases. This causes more signal to shunt to ground.

The control circuitry for the agc consists of an average detector and an rms converter. Depending on the position of the response button, the output of U4051 is switched through FET Q4032 to the average detector or through FET Q4031 to the rms converter. The average detector. It consists of an active rectifier, U4042, with diodes CR4052 and CR4051, and an integrator, U4062A and C5061 with reference current from R5041 and R4042. Amplifier, U4062B in conjunction with C5060, C5062, R5063, R5064 and C5063 with R5065 provides additional filtering of the rectified voltage to reduce distortion introduced by the agc action.

The rms converter consists of U4030, C5021 and R4031 and is also filtered by U4062 and U4062B and associated components.

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.

This circuitry seeks to keep the voltage at the output pin 6 of the 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.

Notch Filter

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 Fiq. 3-1. Operational amplier U4020, and associated resistors and capacitors comprfises a multiple feedback path inverting band pass filter. Amplfier U3010A is an inverting summer. Filter tuning is accomplished in half decads 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 (U4021 A 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.

U3020B feeds back a portion of the notch output to the electric 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 end U3020A.

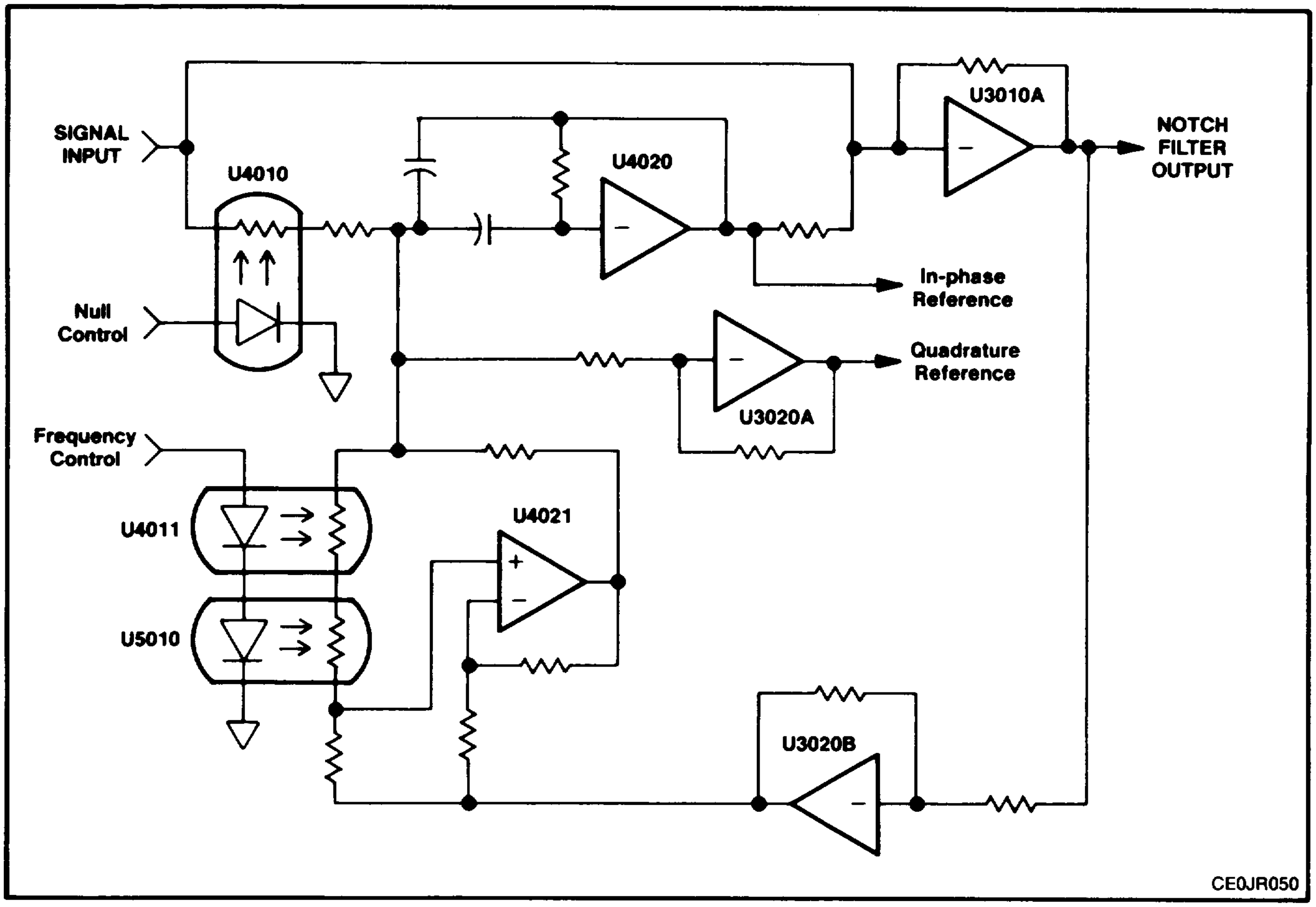


Fig. 3-1. Simplified notch filter.

Frequency Bend Discriminator

The signal from the junction of R2026 and R3021 is squared by a Schmitt trigger, composed of Q1041 and Q1042. The frequency band is determined by measuring the period of the resulting squarewave. 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. 3-2. 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 U2051 B. The last column in Table 3-1 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 R 1515 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 Cl 041 sets the internal clock frequency of U2041 to approximately 7 Hz. The input state to U1400 must be stable for four clock cycles or approximately 0.6 seconds for any change in output to occur.

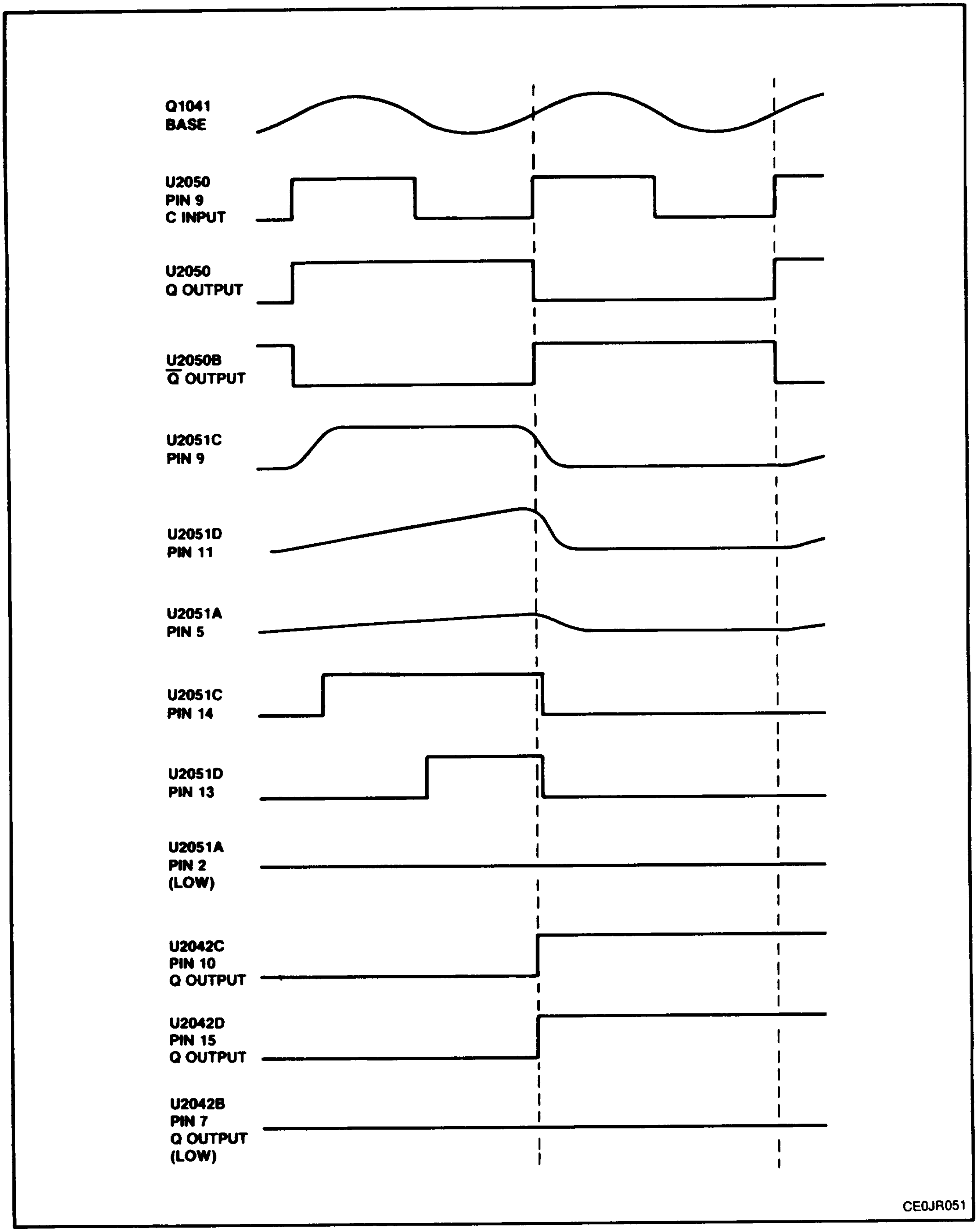


Fig. 3-2. Frequency band discriminator.

Table 3-1
TRUTH TABLE FOR U2042 OUTPUTS

Fin (Hz)	Q 2042A Pin 3	Q U2042C Pin 10	Q U2042D Pin 15	Q 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	H	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

Notch Filter Control

The notch filter is controlled by demodulating the in-phase and quadrature phase (shifted 90 degrees) compnents of the notch filter output referenced to the input fundamental signal. See Fig. 3-1. The in-phase reference inputs to pin 2 of U 1020A, 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.

The notch filter output is amplified by U3010B and U 1011 B. 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 CR 1010 and CR1011. This signal is amplified by Q2010 and filtered by C2011 to control the resistance of FETQ2011, 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.

As stated earlier, the in-phase component of the fundamental derived from the output of the bandpass filter U4020 feeds pin 2 of U 1020A. This circuitry forms a CMOS compatible logic signal to drive the CMOS multiplexer, U1010. The quadrature component of the fundamental derived from U3020A similarly feeds pin 6 of U1020B. The switching arrangements of U1010 are shown in Table 3-2. 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 U 1010 at a rate and phase determined by the quadrature signal at pin 11. The outputs of U 1010 represent the synchronously demodulated in-phase and quadrature components of the fundamental, present in the notch output signal.

These outputs are integrated by U2020A, for the amplitude 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 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 RI 023 and R1030 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.

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.

Table 3-2
INTERNAL CONNECTIONS IN U1010 DEPENDING ON LOGIC STATES OF PINS 10 AND 11

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

Distortion Amplifier

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

Multiplexer U2040, selects the input source for the distortin amplifier. The four sources are: input stage pins 5 and 14, input stage less 10 dB pins 1 and 13 (through R2033 and R2032), THD notch filter pins 2 and 4, and SINAD pins 12 and 15. Control of U2040 is through the level and SINAD switches, as well as the output of U3021A. In both the THD and SINAD, Q2041 turns off to prevent crosstalk.

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 3-3. 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.

Table 3-3
GAIN AND SWITCHING THROUGH U2031

Logic Level Pins 9 10	Total Gain Through Dist Amp	U2041 Gain	Internal Connections pins
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

Filters and Ac-Dc Converters

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, is a peak detector and filter. This dc signal goes to the logic board to control autoranging of the distotion amplifier.

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 3-4 is a truth table for U1021.

Table 3-4
TRUTH TABLE FOR U1021

B	A	ON CHANNELS		
0	0	X0	Y0	WEIGHTING
0	1	X1	Y1	30 kHz LOWPASS
1	0	X2	Y2	80 kHz LOWPASS
1	1	X3	Y3	330 kHz LOWPASS

The highpass filter (three pole 400 Hz Buttenworth) 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.

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 state of the EXT control signal.

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 averaging rectifier is U2030A with diodes CR2031 and CR2032. The rectified output is smoothed and filtered by U2040B, Cl 040, and associated components. The average detector output connects to U2040A via Q3040 in the average response mode, overriding the rms converter.

dB Converter

The dB section is fed by the dc output voltage from the selected detector. The dB converter consists of quad operational amplifier U411 1, 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:

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

K is a constant and Ic 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 Vin = 1.549 Volts), U5101A pin 2 is at 0 V and U4111C pin 8 is at 0 V. The offset voltage of the differential pair and U4111A is adjusted by R8101 (0 dB Adjust), which sets the 0 dB output level. Compensation for the offset voltage of U4111C (– 40dB Adjust) is provided by R8091. This provides correct log conformity at low input voltages. Inversion of the dB output is provided by U4111A. Pin 1 of U4111A also provides the dB voltage to the bar graph display.

The three remaining transistors in U5101 serve as heaters to maintain the differential pair (U5101 A and B) at a constant junction temperature. The voltage at U5101 pin 3 is proportional to the internal temperature of U5101. This voltage is compared with the reference voltage and any error is amplified by U4111B. The amplified error signal drives 03111 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.

dB Offset Generetor

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 dBr section supplied via pin 5 of U2151.

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 to the input of U4121C. This converter is driven by an 11 bit binary counter composed of U6111 and U7111. This counter is controlled by dual flip-flop U7161B which is sup plied with a clock signal from the gated oscillator composed of U7151A and B.

When the dB ratio button is pushed (grounded) a debounce circuit composed of U7151C and D causes pin 3 of U7161A to go high. A short time later, determined by R8131 and C8135, pin 4 of U7161 A goes high, terminating the high at pin 1. A positive pulse appears at U7161 pin 1, resetting counters U6111 and U7111 and flip-flop U7161 B. 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 dBr 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.

6 V Reference

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

DVM

The DVM section accepts the dc voltage from the dB converter or directly from the selected ac to dc oonverter 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. Overrarnge 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 U 1060A 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 left of the most significant digit module is used only in the dB mode with LEVEL and THD + N functions. Q1042 prevents the minus sign from illuminating in any other mode or in the SINAD function.

The ten operational amplifier, 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 +5V.

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, GPIB 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 annunicator LEDs.

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 bat-to-decimal decoder, to drive the input stage gain control lines.

A dc signal, proportionall 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 U7021 A 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 Q2163 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, sums the gain of the input stage and the distortion amplifier. Pins 7, 5, 3 and 6 provide input stage gain information. Pins 4 and 2 provide distortion amplifier gain information. This sum is decoded by U5021, and passes through CR5031, CR5033 and CR5037. These diodes drive U3021 B and U4061 to operate the µV, mV, and V annunicator 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 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 level 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.

Power Supplies

There are three operating voltages in the TS-4084/G: + and – 15 V dc and + 5 V dc. The +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 power supply. A three terminal voltage regulator, U4040, provides +5 V and includes built-in current limiting. Additional overcurrent protection is provided by F4062. R3047 provides adjustment of the voltage to a nominal value of +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 U4041 B and Q4050. The power supply NPN transistor and 03051 form a Darlington series-pass transistor. Frequency compensation for stability is provided by R4050 and C4050. Current limiting is accomplished by 03050 which senses the voltage across R3053. When the current delivered by the +15 volt 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 power supply. Amplifier U4041 A compares the regulated +15 V supply with the – 15 V through R4041 and R4042. Voltage differences are amplified by U4041 and Q4051. The power supply PNP transistor and Q4052 form a Darlington 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 volt 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.

Interface

This circuitry provides an interface between the microprocessor and the Logic Switches.

Data on the state of the filter switches as well as the Mode Defeat, Response Drive, SINAD Drive and Level Drive input at inputs DO 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 Ω resistors are connected between the switches and the level shifters.

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

Unlock Indicator

The output of U2020B in the notch filter control is fed to U2020 used as a ‘window” comparator and controls the “UNLK” light. When the UNLK light is on, the notch filter is not locked onto the input 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 tri-state buffer. When pins 19 and 1 are low the logic ap pearing on the A inputs to the data bus.

The decimal point illuminated appears as a low on the Al and 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 reads the illuminated display segments. U2035A and U2035B serve as level shifters from the eight line display segment decoders. Address decoding is accomplished by U2034.

This 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 and Autorange Control Logic.

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

Main Interface/Power Supply

Ac power is applied to the voltage select terminals through line filter FL500, power switch S500, and thermal cut-out S501. The two primary windings on T500 are connected in parallel for 115 V operation or in series for 230 V operation. Winding taps are provided for various line voltages around the nominal values.

One set of secondary windings on T500 is full-wave rectified and filtered by CR3021, CR4011, and C2051, then pm-regulated by VR1031 and 0510 to provide +8 Vdc to the instrument. The remaining secondary winding of T500 is full-wave rectified and filtered by CR3011, Cl011, and C2031 and supplies the un-regulated + and – 33 Vdc to the instrument. VR2011, CR2011, and Q500 supply a regulated 24 Vdc to operate the dc fan.

Section 4

PERFORMANCE CHECKS AND ADJUSTMENTS

Introduction

This procedure checks the electrical performance requirements as listed in the Specification section of this manual and may be used in an incoming inspection facility to determine acceptability of performance. If the instrument fails to meet the requirements given in this Performance Check section, the Adjustments Procedure section should be performed. This procedure can be performed at any ambient temperature between 0 deg. C to + 50 deg. C. Allow 20 minutes warm-up time (60 minutes after storage in a high-humidty environment) before beginning the Performanoe Check.

Test Equipment Required

The test equipment, or equivalent (except as noted) listed in Table 4-1 is suggested to perform the Performance Check and the Adjustment Procedure in this manual.

Table 4-1
CROSS REFERENCE FOR TEST EQUIPMENT

Description	Suggested	MAC Listing
Low Distortion Sinewave Oscillator	Tektronix SG5010	SG505
Oscilloscope	Tektronix SC 504	5440
Function Generator	Tektronix FG 501A or FG 504	FG502
Controller	Tektronix 4052A or 4041	1722/AB
AC Voltage Calibrator	Fluke 5200A & 5205A	745A
General Purpose Digital Multimeter	Tektronix DM 501A	DM 501A
General Purpose Counter	Tektronix DC 509 or DC 504A	DC503A OPT 1
Adapter, bnc female-to-dual banana	Tektronix 103-0090-00	7907471
Bnc T-Adapter	Tektronix 103-0030-00	103-0045-00
Extender Cable	Tektronix 067-0645-02	067-0645-02
Bnc Connectors, 50 Ω coaxial cables; 42 inch, 2 ea.	Tektronix 012-0057-01	SMI 1589-72
6-inch banana-to-banana Patch Cord	Tektronix 012-0024-00	7907470

Table 4-1 (cont.)

Description	Suggested	MAC Listing
50 Ω Feedthrough Termination	Tektronix 011-0049-01	011-0049-01
500 10 X Attenuator, 2 ea.	Tektronix 011-0059-02	011-0059-02
1 MΩ/20 pF Input Normalizer	Tektronix 067-0538-00	067-0538-00

Performance Check Steps

1. Check (Input Impedance
2. Check common Mode Rejection
3. Check Level Function Volts Accuracy
4. Check dBm Accuracy and Flatness
5. Check Bandwidth
6. Check Filters Response Accuracy
7. Check Residual Noise
8. Check THD+N Accuracy
9. Check Residual THD+N
10. Check Input Monitor
11. Check Function Output
12. Check Auxillary Input

NOTE

The TS-4084/G has measurement response. Unless specfically noted, all performance specificatios and check are valid using rms response only.

TS-4084/G Performance Check Summary

Serial Number: ______________________ **Notes:** ______________________

Date: ______________________ ______________________

STEP	CHECK	ALLOWABLE LIMITS	ACTUAL VALUE
1.	**Input Impedance**		
	+ Input	98.0 to 102.0 kΩ	
	– Input	98.0 to 102.0 kΩ	
2.	**Common Mode Rejection**		
	50 mV (200 µV range)	± 1.58 V	
	50 mV (2 mV range)	±158 mV	
	50 mV (20 mV range)	±15.8 mV	
	100 mV (200 mV range)	±3.2 mV	
	300 mV (600 mV range)	±1.0 mV	
	1 V (2 V range)	±3.2 mV	
	3 V (6 V range)	±1.0mV	
	10 V (20 V range)	±3.2 mV	
	30 V (60 V range)	±1.0mV	
	100 V (200 V range)	±3.2 mV	
3.	**Volts Accuracy**		
	A. 20 Hz to 20 kHz band	20 Hz 1 kHz 20 kHz	
	100 µV (200 µV range)	97.9 to 102.1 µV	
	1.8 mV (2 mV range)	1.763 to 1.837 mV	
	18 mV (20 mV range)	17.63 to 18.37 mV	
	160 mV (200 mV range)	176.3 to 163.7 mV	
	500 mV (600 mV ranga)	469 to 511 mV	
	1.800 V (2 V range)	1.763 to 1.837 v	
	5.00 V (6 V range)	4.89 to 5.11	
	18.00 V (20 V range)	17.63 to 18.37	
	50.0 V (60 V range)	48.9 to 51.1	
	180.0 V (200 V range)	176.3 to 163.7	

STEP #	CHECK	ALLOWABLE LIMITS	ACTUAL VALUE
	B. 10 Hz to 100 kHz	10 Hz 100kHz	
	100 μV (200 μV range)	95.8 to 104.2 μV	
	1.8 mV (2 mV range)	1.727 to 1.873 mV	
	18 mV (20 mV range)	17.27 to 18.73 mV	
	160 mV (200 mV range)	172.7 to 187.3 mV	
	500 mV (600 mV range)	479 to 521 mV	
	1.800 V (2 V range)	1.727 to 1.873 V	
	5.00 V (6 V range)	4.79 to 5.21	
	18.00 V (20 V range)	17.27 to 18.73	
	50.00 V (60 V range)	47.9 to 52.1	
	160.00 V (200 V range)	172.7 to 187.3	
4.	**dBm Accuracy and Flatness** A. 0.7746 V, 1 kHz	–0.3 to +0.3 dBm	
	24.50 mV, 1 kHz	–30.3 to –29,7 dBm	
	B. Flatness 10 Hz	–0.5 to +0.5 dB	
	20 Hz	–0.3 to +0.3 dB	
	20 kHz	–0.3 to +0.3 dB	
	100 kHz	–0.5 to +0.5 dB	
	C. 100 dB Rato Accuracy	– 100.7 to –99.3 dB	
5.	**Bandwidth**	**300 kHz**	
6.	**Filters Response Accuracy** A. 400 Hz HI PASS –3dB 60 Hz rejection	360 to 420 Hz ≤ –40dB	
	B. 60 kHz LO PASS –3dB	76 to 84 kHz	
	C. 30 kHz LO PASS –3dB	28.5 to 31.5 kHz	
	D. A WTG 100 Hz	–20.1 to –18.1 dB	
	1 kHz	–1.0 to +1.0 dB	
	10 kHz	–6.5 to –0.5 dB	

STEP #	CHECK	ALLOWABLE LIMITS	ACTUAL VALUE
7.	**Residual Noise**		
	400 Hz – 80 kHz	< 3.0 µV	
	A WTG	< 1.5 µV	
8.	**Total Harmonic Distortion Accuracy**		
	A. 20 Hz fundamental		
	40 Hz	0.900 to 1.100%	
	60 Hz	0.900 to 1.100%	
	80 Hz	0.900 to 1.100%	
	1 kHz	0.900 to 1.100%	
	B. 1 kHz fundamental		
	2 kHz	0.900 to 1.100%	
	3 kHz	0.900 to 1.100%	
	4 kHz	0.900 to 1.100%	
	10 kHz	0.900 to 1.100%	
	C. 20 kHz fundamental		
	40 kHz	0.900 to 1.100%	
	60 kHz	0.900 to 1.100%	
	80 kHz	0.900 to 1.100%	
	100 kHz	0.900 to 1.100%	
	D. 10 Hz fundamental		
	20 Hz	0.800 to 1.200%	
	100 Hz	0.800 to 1.200%	
	E. 100 kHz fundamental		
	200 kHz	0.800 to 1.200%	
	300 kHz	0.800 to 1.200%	

STEP #	CHECK	ALLOWABLE LIMITS	ACTUAL VALUE	
9.	**Residual THD+N**		−Input Grounded	+Input Grounded
	10 Hz	≤0.015%		
	20 Hz	≤0.005%		
	1 kHz	≤0.005%		
	20 kHz	≤0.005%		
	50 kHz	≤0.015%		
	100 kHz	≤0.015%		
10.	**Input Monitor**			
	Amplitude	0.90 to 1.10 V		
	Output Impedance	950 to 1050 Ω		
11.	**Function Output**			
	Accuracy	0.97 to 1.03 V		
	Output Impedance	570 to 630 Ω		
12.	**Auxiliary Input**			
	Accuracy	0.97 to 1.03 V		
	Input Impedance	95 to 105 k Ω		

PERFORMANCE CHECK PROCEDURES

1. Check Input Impedance

NOTE

Ground terminal signifies chassis ground throughout these procedures.

TS-4084/G Control Settings

FUNCTION	Level-volts
INPUT RANGE	200 mV
FILTERS	None
RESPONSE	RMS

a. Connect the ac voltage calibrator to the input terminals of the TS4064/G. Jumper negative terminal to the ground terminal on the TS-4084/G.

b. Set the ac calibrator for an output frequency of 400 Hz and an amplitude of 110 mV. Adjust calibrator amplitude until the TS-4064/G display reads exactly 110.0 mV.

c. **Insert the 1MΩ/20 pF Normalizer in series with the** BNC to banana plug adapter. Set the ac calibrator range for an output amplitude equal to 10 times the reading obtained in step 1b.

d. CHECK – that the TS4084/G display readout is 98.0 to 102.0 mV, corresponding to an input impedance of **98.0 to 102.0 kΩ.**

e. Reverse the banana plug connections to the TS-4064/G so that the grounding connection shorts out the + input.

f. CHECK – that the TS-4064/G display readout is 98.0 to 102.0 mV corresponding to an input impedance of **98.0 to 102.0 kΩ.**

g. Remove the 1 **MΩ/20** pF Normalizer.

2. Check Common Mode Rejection

a. Connect the ac voltage calibrator output to the positive" terminal and the ground terminal of the TS4084/G. Jumper the negative terminal to the positive terminal on the TS-4084/G.

b. Connect the digital multimeter to the TS4084/G Function Output and set it to measure ac volts.

c. Set the ac calibrator for an output frequency of 50 Hz (or 60 Hz) and an amplitude of 50 mV.

d. Set the TS-4084/G INPUT RANGE switch to 200 µV.

e. CHECK – that the digital multimeter displays 1.560 volts or less.

NOTE

The internal gain from the TS-4084/G *INPUT* to the *FUNCTION OUTPUT is 80 dB (x* 10,000) on the *200 µV range. With 50* mV *of common rnode signal, 50 dB rejection would correspond to an equivalent inputs signal of 158A V. This is amplified by 80 dB* to *1.58 V. Other Input Ranges decrease this gain in inverse proportion to their value.*

f. CHECK – that when using Table *4-2,* the digital multirneter readings are acceptable for the listed input conditions.

NOTE

DECREASE RANGE lamp will be on throughout this procedure.

Table 4-2
COMMON MODE REJECTION CHECK

TS-4084/G Input Range	Input Common Mode Voltage	Maximum DVM Reading
200 µV	*50* mV	1.58V
2 mV	50 mV	158 mV
20 mV	50 mV	15.8 mV
200 mV	0.1V	3.2 mV
600 mV	0.3V	1.0 mV
2 V	1 V	3.2 mV
6 V	3 V	1.0 mV
20 v	10V	3.2 mV
60 V	30 v	1.0 mV
200 v	100 v	3.2 mV

3. Check Level Function Volts Accuracy

a. Connect an ac voltage calibrator output to the TS-4064/G input. Jumper negative terminal to the ground terminal of the TS-4084/G.

b. Set the voltage output of the ac calibrator and the TS-4084/G INPUT RANGE switch as shown in Table 4-3, and check that the displayed voltage readings are within the limits shown in the following table using 10 Hz, 20 Hz, 1 kHz, 20 kHz, and 100 kHz frequencies.

NOTE

The operational range and/or specified accuracy of most commercially available voltage calibrators is not adequate to directly check the TS-4084/G performance at 100 µV. If desired, an accurate 100 µV signal may be obtained by connecting a 1 kΩ 0.1% resistor shunting the TS-4084/G INPUT and a 100 kΩ, 0.1% resistor in series with the ac voltage calibrator set for 0.20 mV. The resistor divider ratio (including TS-4084/G input impedance effects) will 102 to 1 causing the required 100 µV at the input terminals.

c. Maintain test setup for next oheck.

4. Check dBm Accuracy and Flatness

a. Connect an ac voltage calibrator output to the TS-4084/G input. Jumper negative terminal to the ground terminal of the TS-4084.

b. Set the ac calibrator output frequency to 1 kHz with an amplitude of 0.7746 v.

c. Change the TS-4084/G INPUT RANGE switch to AUTO RANGE and the LEVEL FUNCTION to dBm 600 Ω.

d. CHECK – that the dBm reading is –0.3 to +0.3.

e. Bet the ac calibrator for an output frequency of 1 kHz and any valid voltage ≥100 µV. Calculate the dBm equivalent of this voltage using the formula:

$$dBm = 20 \times \log_{10}\left(\frac{\text{Input V}}{0.7746}\right)$$

For example 24.50 mV would correspond to –30.0 dBm.

f. CHECK – that the dBm reading is within ±(0.3 dB) of the calculated result in step 40.

Table 4-3
LEVEL FUNCTION VOLTS ACCURACY

TS-4084/G Input Range	Calibrator Setting	Reading Limits	
		20 Hz-20 kHz	10 Hz – 100 kHz
200 µV	100.0 µV	97.9 to 102.1	95.8 to 104.2
2 mV	1.800 mV	1.763 to 1.837	1.727 to 1.873
20 mV	18 mV	17.63 to 18.37	17.27 to 18.73
200 mV	160 mV	176.3 to 183.7	172.7 to 187.3
600 mV	500 mv	469 to 511	479 to 521
2 V	1.800 V	1.763 to 1.837	1.727 to 1.873
6 V	5.00 V	4.69 to 5.11	4.79 to 5.21
20 V	18.00 V	17.63 to 18.37	17.27 to 18.73
60 V	50.0 V	46.9 to 51.1	47.9 to 52.1
200 V	160.0 V	176.3 to 183.7	172.7 to 187.3

g. Select dB RATIO display mode and PUSH TO SET 0 dB REFerence set button.

h. CHECK – that the dB reading is –0.3 to +0.3 at 20 Hz and 20 kHz, and –0.5 to +0.5 at 10 Hz and 100 kHz frequency settings of the sc calibrator.

i. Set the ac calibrator to 100.0 Volts and 1 kHz and PUSH TO SET 0 dB REFerence set button.

j. Set the ac calibrator to 1.000 mV

k. CHECK – that the dB reading is –99.3 to – 100.7.

5. Check Bandwidth

a. Connect function generator to TS-4084/G input using a 50 Ω terminator and BNC-to-dual banana plug adapter. Connect the frequency counter to the TS-4084/G Input Monitor.

b. Set function generator output to a 1 kHz sinewave and any convenient amplitude, such as 1 V. Adjust for a stable frequency readout.

c. Select the dB RATIO display mode and PUSH TO SET 0 dB REFerence set button.

d. Increase the frequency of the function generator until the display readout indicates –3.0 dB.

e. CHECK – that the digital counter frequency readout indicates ≥300 kHz.

f. Disconnect test equipment.

6. Check Filters Response Accuracy

a. Connect the sinewave oscillator output to the TS-4064/G INPUT. Connect frequency counter to the TS-4084/G input monitor.

b. Set the sinewave oscillator frequency to 1 kHz and any convenient amplitude, such as 1 V.

c. Select dB RATIO display mode and PUSH TO SET 0 dB REFerence set button.

d. Press the 400 Hz HI PASS filter button.

e. Decrease the frequency of the sinewave oscillator until the display readout indicates – 3.0 dB.

f. CHECK – that the frequency counter readout indicates between 380 Hz and 420 Hz.

g. Decrease the frequency of the sinewave oscillator to 60 Hz.

h. CHECK – that the TS4064/G display readout indicates 40 dB or more attenuation.

i. Release the 400 Hz HI PASS filter and select the 80 kHz LO PASS filter.

j. Increase the frequency of the oscillator until the display readout indicates –3.0 dB.

k. CHECK – that the frequency counter reads 76 kHz to 64 kHz.

l. Release the 80 kHz LO PASS filter and select the 30 kHz LOW PASS filter.

m. Decrease the frequency of the oscillator until the display readout indicates -3.0 dB.

n. CHECK – that the frequency counter reads 28.5 kHz to 31.5 kHz.

0. Release the 30 kHz filter and select the AWTG filter.

p. Set frequency of the sinewave oscillator to 100 Hz.

q. CHECK – that the TS-4084/G display readout indicates –20.1 dB to –18.1 dB.

r. Set sinewave oscillator frequency to 1 kHz.

s. CHECK – that the TS-4084/G display readout indicates - 1.0 dB to +1.0dB.

t. Set sinewave oscillator frequency to 10 kHz.

u. CHECK – that the TS-4084/G display readout indicates –6.5 dB to –0.5 dB.

v. Release AWTG filter.

7. Check Residual Noise

a. Disconnect all cables from the TS-4084/G. Connect a shorting bar across the + and – Input terminals.

b. Set the TS-4084/G INPUT RANGE to 200 µV or the AUTO RANGE position. Select VOLTS display, RMS RESPONSE and both 400 Hz HI PASS and 80 kHz LO PASS filters.

c. CHECK – that the display readout indicates **<3.0** µV.

d. Release the 400 Hz HI PASS and SO kHz LO PASS filters.

e. Select the AWGT filter.

f. CHECK – that the display readout indicates **<1.5** µV.

8. Check Total Harmonic Distortion Accuracy

a. Connect test equipment as shown in Fig. 4-1.

b. Select Input AUTO RANGE, LEVEL FUNCTION (VOLTS display mode), with no FILTERS.

c. Turn the oscillator output off.

d. Set the function generator output for a 7.00 kHz sinewave and adjust its output amplitude for a TS-4084/G display readout of approximately 3.00 mV, and note reading.

e. Turn on the sinewave oscillator output and set its frequency to 400 Hz and amplitude for a TS-4084/G display readout of 300 mV (of exactly 100 times the value set in step 8d).

NOTE

Do not disturb fhe sinewave oscillator or function generator output amplitudes for the remainder of this step. The resultant composite two tone signal comprises a calibrated 1.00% distortion source.

f. Select THD+N FUNCTION and AUTO RANGE.

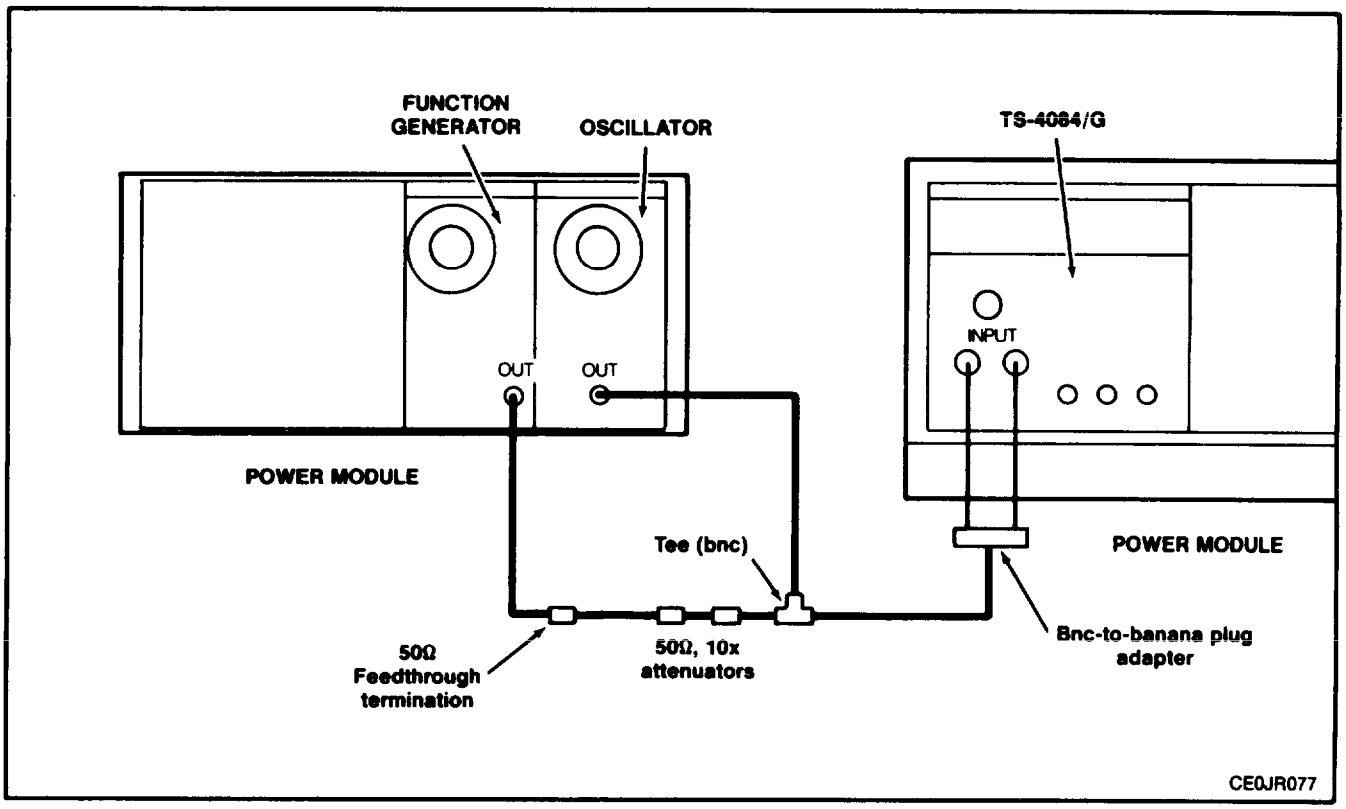


Fig. 4-1. TS-4084/G check/adjust setup.

g. CHECK – That the displayed distortion readout is within the limits at the various suggested frequency combinations as shown in Table 4-4.

NOTE

When checking measurement accuracy, carefully set the test frequency as close as possible to be in exact harmonic ratio with the fundamental frequency. Beat frequency related display jitter can occur if the test frequency is *offset by 0.1 Hz to* 5 *Hz from an exact harmonic. This is caused by the TS-4084/G automatic tuning and nulling* control loops and *the relatively fast response of the response detectors. A* Lissajous *waveform, formed by an X– Y display of the Input Monitor and Function Output signals may be helpful in setting* the frequencies for exact harmonic *ratios.*

Table *4-4*
TOTAL HARMONIC DISTORTION ACCURACY CHECK

Fundamental (Oscillator)	Teat Frequency (Function Generator)	Reading Limits
20 Hz	40 Hz 60 Hz 80 Hz 1 kHz	0.900% to 1.100%
1 kHz	2 kHz 3 kHz 4 kHz 10 kHz	
20 kHz	40 kHz 80 kHz 80 kHz 100 kHz	0.900% to 1.100%
10 Hz	20 Hz 100 Hz	0.800% to 1.200%
100 KHz	200 kHz 300 kHz	

h. Maintain test setup for next check.

9. Check Residual THD + N

a. Connect the sine-wave oscillator output to the TS-4084/G input. Jumper negative terminal to the ground terminal of the TS-4084/G.

Sinewave Oscillator Control Settings

OUTPUT LEVEL	any setting >250 mV, eg.0 dBm
GND-FLTG	FLTG
ON-OFF	ON

TS-4084/G Control Settings

INPUT RANGE	AUTO
FUNCTION	THD + N
%	Auto Range

b. CHECK – that the TS-4084/G displayed readout does not exceed the limits as shown in Table 4-5 for the frequencies specified and for the TS-4084/G filter used.

Table 4-5
RESIDUAL THD + N CHECK

Oscillator Freq.	TS-4084/G Filter	TS-4084/G THD + N Reading Limit
10 Hz	None	0.01570
20 Hz	80 kHz	0.005%
1 kHz	80 kHz	0.005%
20 kHz	80 kHz	0.005%
50 kHz	None	0.015%
100 kHz	None	0.015%

c. Reverse the banana plug connections to the TS-4084/G so that the grounding connection shorts out the + input.

d. Repeat step 9b.

10. Check Input Monitor

a. Connect the sinewave oscillator to the TS-4084/G input and the digital multimeter to INPUT MONITOR.

b. Select the 2 V INPUT RANGE and LEVEL FUNCTION.

c. Set the sinewave oscillator output frequency to 1.00 kHz and approximately 1 V rms, as displayed on the TS-4084/G.

d. Set the digital multimeter to measure ac volts.

e. CHECK – that the digital multimeter displays 0.90 to 1.10 V rms.

f. Turn the oscillator output off.

g. Set the digital multimeter to measure resistance.

h. CHECK – that the digital rnultimeter displays 950 to 1050 Ω.

NOTE

A slight dc offset may present at the Input Monitor and will affect resistance measurement. To prevent measurement error, take the average of two readings reversing the digital rnultimeter connections between readings.

11. Check Function Output

a. Connect digital multimeter to the TS-4084/G function output.

b. Set the digital multimeter to measure ac volts.

c. Turn on the sinewave oscillator output and adjust its amplitude for a TS4084/G display readout of 0.998 V to 1.002 V.

d. CHECK – that the digital multimeter displays 0.97 to 1.03 V.

e. Turn the oscillator output off.

f. Set the digital multimeter to measure resistance.

g. CHECK – that the digital multimeter displays 570 to 830 Ω.

h. Disconnect test equipment.

NOTE

A slight dc offset may be present at the Function Output and will affect a resistance measurement. To prevent measurement error, take the average of two readings reversing the digital multimeter connections between readings.

12. Check Auxiliary Input

a. Connect an ac voltage calibrator to the TS-4084/G AUXILIARY INPUT. Set the ac voltage calibrator output frequency to 400 Hz and 1.000 V amplitude.

b. Select 2 V INPUT RANGE, LEVEL FUNCTION (VOLTS mode), and EXT. FILTER.

c. CHECK – that the TS-4084/G displays 0.970 to 1.030 V.

d. Adjust sc voltage calibrator amplitude until the TS-4084/G displays exactly 1.100V.

e. Insert the 1 M Ω/20 pF Normalizer in series with the Auxiliary Input.

f. CHECK – that the TS-4084/G display readout is 0.095 to 0.105 V, corresponding to an input impedance of 95 to 105 kΩ.

This completes the Performance Check

ADJUSTMENT PROCEDURE

Introduction

This procedure need not be performed unless the instrument fails to meet the performance requirements of the electrical characteristic listed in the Specification Table (Table 1-1). Adjustment may be required after a repair has been made. If adjustment of internal controls does not bring the instrument performanoe within the limits listed in the Specification section, troubleshooting is indicated. Adjustments should be made with the instrument operating at an ambient temperature of +20 deg. C to +30 deg. C.

Test Equipment Required

Teat equipment used for adjustment of the TS-4084/G is listed in Table 4-1 and Maintenance Allocation chart (Appendix D).

Preparation

To gain access to the test points and adjustable components, refer to the Maintenance section for disassembly instructions (removing the distortion analyzer from the power supply and removing the distortion analyzer side covers). Some adjustments are accessible through the top and bottom oovers. See Fig. 4-2.

Connect the distortion analyzer to the power supply via the extender cable. Connect the test equipment and the power supply to a suitable line voltage source.

Turn on the power supply and test equipment; allow at least 30 minutes warm-up time for the TS-4084/G.

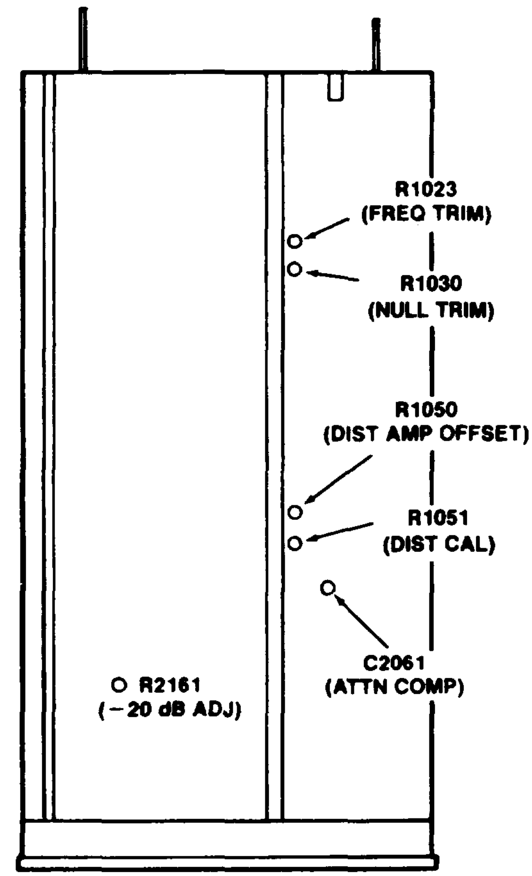


Fig. 4-2. TS-4084/G top cover adjustments access.

PROCEDURE

1. + 5.25 V (R3047) ADJUSTMENT

a. Connect the digital voltmeter positive lead to the + 5.25 V test point (TP 3041) (FO-10) and the negative lead to ground (TP 3044) (FO-10).

b. ADJUST — R3047, located on the Main board (FO-10), for a display of 5.25 V, ± 0.1 V.

c. Remove all cable connections.

2. Distortion Amp Offset (R1050) ADJUSTMENT

TS-4084/G Settings

FUNCTION	THD+N
%	0.2%
FILTERS	80 kHz LO PASS
INPUT RANGE	2 V

a. Short the TS-4084/G INPUT terminals using the dual banana shorting bar.

b. Connect cable from the oscilloscope vertical plug-in to the TS-4084/G FUNCTION OUTPUT connector.

c. Set the oscilloscope for 200 mV/div, dc coupling (vertical) and 200 ms/div (horizontal). Adust timebase for auto trigger and position the displayed baseline near center screen.

d. Press the TS-4084/G AUTO RANGE 2% button and note the jump and recovery of the displayed waveform baseline.

e. ADJUST – R1050, accessible through a hole in the top cover (sea Fig. 4-2) and located on the Input/Notch Filter board, while alternately pressing the 0.2% and 20/. AUTO RANGE buttons for a jump amplitude of less than 100 mV.

f. Remove all corrections.

3. Rms Zero (R1030), Avg Zero (R1035) ADJUSTMENTS

a. Press the TS-4084/G FUNCTION LEVEL and VOLTS buttons.

b. Connect cable from the ac voltage calibrator output to the TS-4084/G INPUT terminals. Set the ac voltage calibrator for a 15.00 mV, 1 kHz (sinewave) output.

c. Press the TS-4084/G RESPONSE button (RMS position).

d. ADJUST – R1030 (located on Mainboard, FO-10), for a display readout of .014 V; then slowly adjust R1030 until .015 reading is attained.

e. Press the FUNCTION dBm 600 Ω button, and note the display readout.

f. Release the RESPONSE button.

g. ADJUST – R1035 (located on the Main board) (FO-10), for the same reading as noted in step 3e.

h. Maintain same test setup.

4. Rms Cal (R2064), Avg Cal (R1040) ADJUSTMENTS

a. Press the TS-4084/G FUNCTION LEVEL and VOLTS, and set the INPUT RANGE switch to 2 V.

b. Press the RESPONSE button (RMS position).

c. Set the ac voltage calibrator for a 1.500 V rms output.

d. ADJUST - R2064, located on the GPIB board (FO-12), for a display readout of 1.500 V, ± 0.001.

e. Release the RESPONSE button.

f. ADJUST – R1040 located on the Main board (FO-10), for a display readout of 1.500 V, ±0.001.

g. Maintain same test setup.

5. Attn Comp (C2061) ADJUSTMENT

a. Press the FUNCTION LEVEL, VOLTS, RESPONSE (RMS position) buttons and make certain all FILTER buttons are out (off).

b. Sat the INPUT RANGE switch to 2 V.

c. Set the ac voltage calibrator for a 1.00 V, 60 kHz (sinewave) output.

d. Note the display readout.

e. Change the INPUT RANGE switch to 20 V.

f. Change the ac voltage calibrator to 10.00 V (60 kHz).

g. ADJUST – C2061 (Fig. 4-2), for a display readout equal to exactly ten times the reading noted in step 5d.

h. Maintain same test setup.

6.0 dB (R8101), –20 dB (R2161), and –40 dB (R8091) ADJUSTMENTS

a. Make certain the FUNCTION LEVEL button is pressed.

b. Press the FUNCTION dBm 600 Ω button.

c. Set the ac voltage calibrator for a 0.7746 V rms, 1 kHz output.

d. Set the INPUT RANGE switch to 2 V.

e. Press the RESPONSE (RMS position) button.

f. ADJUST - R8101, located on the Logic board (FO-8), for a display readout of exactly 00.0 dBm.

g. Reduce the calibrator amplitude to 77.46 mV rrns.

h. ADJUST – R2161 (Fig. 4-2), for a display readout of exactly – 20.0 dBm.

i. Reduce the calibrator amplitude to 7.746 mV rms.

j. ADJUST – R8091, located on the Logic board (FO-8), for a display of –40.0, ± 0.2.

k. Interaction – Repeat steps 6e through 6j, until the displays are correct.

l. Maintain same test setup.

7. Offset Gain (R8111) ADJUSTMENT

a. Set the ac voltage calibrator output signal to 7.746 mV rms.

b. Set the INPUT RANGE switch to 20 mV.

c. ADJUST – R8111, located on the Logic board (FO-8), for a display readout of exactly – 40.0 dBm.

d. Maintain same test setup.

8. dBr *Zero* (R8153) ADJUSTMENT

a. Press the TS-4084/G FUNCTION dB Ratio button.

b. Set the INPUT RANGE Switch to 2V.

c. Set the calibrator output to 0.7746 V rms at 1 kHz.

d. Press and release the PUSH TO SET 0 dB REF button.

e. ADJUST – R8153, located on the Logic board (FO-8), for a display readout of exactly 00.0.

f. Interaction – Repeat steps 8d and 8e until the display readout indicates 00.0.

g. Remove all connections.

9. Null (R1030), Freq Trim (R1023), and Ldr Balance (R5025) ADJUSTMENTS

a. Set the INPUT RANGE switch to 2 V and press the THD+N, 0.2%, and 80 kHz LO PASS.

b. Connect the sinewave oscillator to the TS-4084/G INPUT through a BNC to banana plug adapter. Jumper negative terminal to the ground terminal of the TS4084/G. On the sinewave generator, set the GNDED/FLTG switch to the FLTG position.

c. Sat the oscillator output frequency to 400 Hz at approximately 0 dBm (1.55 V rms) amplitude.

d. ADJUST – R1030 (Fig. 4-2), for the lowest display readout.

e. ADJUST – R1023 (Fig. 4-2) for the lowest display readout.

f. INTERACTION – Repeat steps 9d and 9e to obtain the lowest display reading.

g. Change the oscillator frequency to 800 Hz.

h. ADJUST – R5025, accessible through hole in the bottom cover (input/Notch Filter board), for the lowest display readout.

NOTE

If R5025 has no effect on the display readout, leave the adjustment in the *center position.*

i. Disconnect the oscillator.

10. Dist Cal (R1051) ADJUSTMENT

a. Set the INPUT RANGE switoh to AUTO RANGE.

b. Press the FUNCTION LEVEL, VOLTS, RESPONSE and AUTO RANGE buttons. All other buttons are out (position).

c. Connect the teat equipment as shown in Fig. 4-1.

d. Turn off the sinewave oscillator output and make certain the GNDED/FLTG switoh is in the FLTG position.

e. Adjust the function generator for a sinewave output frequency of 7 kHz and a TS-4084/G display of approxirnately 3.00 mV, and note reading.

f. Turn on the sinewave oscillator output and set the frequency to 400Hz. Adjust the output level to 300 mV or exactly 100 times the level set in step 10e (as displayed on the TS-4084/G) and press the THD+N button.

g. ADJUST – R1051, accessible through the top cover hole (Fig. 4-2) for a display readout of 1.000%.

h. Disconnect all test equipment.

This completes the Adjustment Prooedure

Section 5

MAINTENANCE

Introduction

This section of the manual describes on-board jumpers and rear interface information and provides general maintenance and troubleshooting information.

CAUTION

To prevent damage to the TS-4084/G, turn off the power supply before installing or removing the distortion analyzer. Do not use excessive force to install or remove.

Preparation For Use

The line filter assembly is located on the rear panel of the TS-4084/G. The assembly allows aocess to the line fuse and a line voltage selector board. The board position and the fuse rating can be selected to allow the TS-4084/G to operate at any one of four line voltage ranges. These ranges and fuse ratings are listed in Table 5-1.

The following information describes how to remove the line fuse. This information is followed by a procedure for checking the line voltage range selection and rernoving and re-positioning the line voltage selector board to select a different operating voltage range.

CAUTION

The line selector setting (line voltage selector board position) and the the rating must comply with the setting and rating listed in Table 5-1 for the available operating line voltage. Non-compliance can result in damage to TS-4084/G circuitry.

Line Voltage Fuse Removal/Installation. Refer to Fig. 5-1 and the following information.

1. Locate the line filter assembly located on the TS-4084/G rear panel.
2. Disconnect the line cord.
3. Slide the plastic window over the recessed line voltage plug.
4. Remove the fuse by pulling out on the FUSE PULL lever, as shown in the illustration.
5. To install a fuse, return the FUSE PULL lever to its previous (normal) position.
6. Press the fuse into the fuse holder.
7. Slide the plastic window back over the recessed fuse area.
8. Re-connect the line cord.

Table 5-1
LINE VOLTAGE RANGE SELECTION

Line Selector 8etting (Color)	Voltage Range	Fuse F500 250 V Rating
100 V (BLUE)	90— 110Vac	0.6A slow-blow
120 V (GREEN)	106— 132 Vac	0.6A slow-blow
220 V (YELLOW)	200 — 240 Vac	0.3A mad-blow
240 V (RED)	220 — 260 Vac	0.3A reed-blow

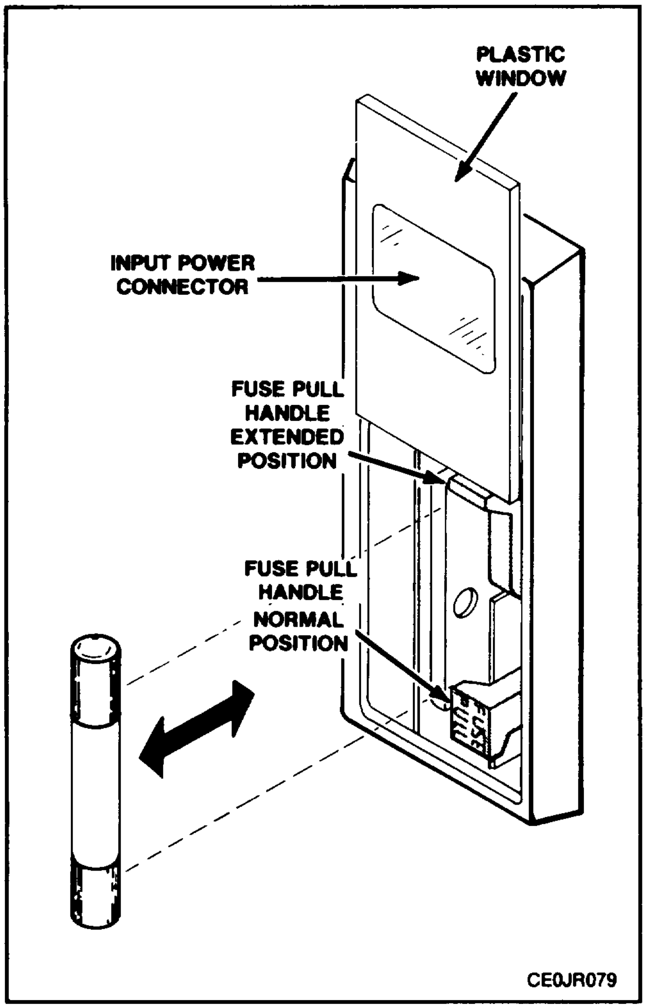


Fig. 5-1. Fuse removal/installation.

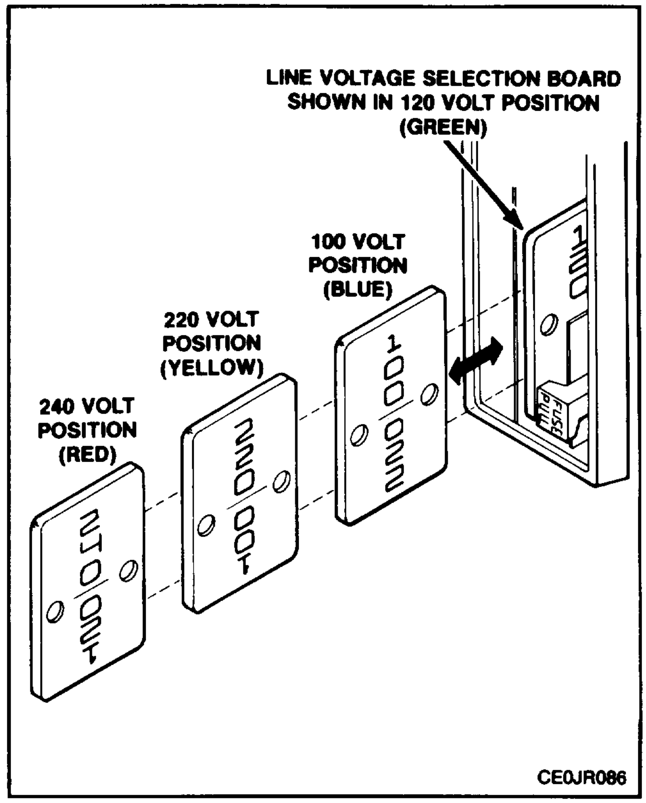


Fig. 5-2. Line voltage range selection.

Line Voltage Range Check/Selection. Refer to Fig. 5-2 with the following procedure. The line filter assembly containing the line voltage selector board is located on the TS-4084/G rear panel.

To check the setting of the line voltage selector board, look through the plastic window and determine both the color and the number visible near the top of the board. The line selector settings and their associated colors are listed in Table 5-1.

To change the line selector board position:

1. Remove the fuse, as described in the preceding procedure (under the heading "Line Voltage Fuse Removal/Installation").

2. Using an extractor tool, carefully pull the line selector board out of the assembly.

3. Referring to Fig. 5-2 and Table 5-1, determine the correct position for the desired line voltage range.

4. With the board correctly oriented, place it in the line filter assembly and press firmly on the edge of the board to seat it in the board connector.

5. Re-install the fuse (with the correct rating), acoording to the preceding procedure.

On-Board Jumpers

Refer to the pull-out pages of this manual.

GPIB board:

J1010 µCom (TS-4084/G/Oscillator Serial interface) - Used to enable or disable communication between the TS-4084/G and Oscillator during sweep mode.

J3020 SA/NORM - Used to enable signature analysis routine internal to the TS-4084/G.

J3023 RUN/FORCE Instruction Mode Test - Used to initiate forced instruction mode test.

DISTORTION ANALYZER
REAR INTERFACE INFORMATION

FUNCTIONS AVAILABLE AT REAR CONNECTOR

Refer to Fig 5-3 for the GPIB board assignments and Fig. 5-4 for the Main board assignments.

Slots exist between pins 17 and 18, 13 and 14, and 6 and 7 on the rear interface connector. Signal inputs, outputs, or other specialized connections may be made to the rear interface connector as shown in the input output assignments illustration (Fig. 5-4). A description of these connections follows.

+ and - Input Connectors (28B, 28A)

These terminals are connected to the input of the TS-4084/G when the REAR INTFC INPUT button on the front panel is pressed. The front panel INPUT connectors are disconnected in this mode. The characteristics of these terminals are identical with the front panel INPUT connectors except the maximum input voltage is limited to 42 V peak or 30 V rms. Due to the possibility of crosstalk at the rear interface, noise and distortion performance may be degraded.

Input Common (27B, 27A)

These are the common (ground) connections for the rear interface input.

Auxiliary Input (25B)

This terminal is connected in parallel with the front panel AUXILIARY INPUT connector. Maximum input voltage is 15 V and limited to 6 V peak for linear operation.

Auxiliary Input Ground (26B)

Use this connection as a ground return for the auxiliary input.

Function Output (23B)

This connector is in parallel with the front panel FUNCTION OUTPUT connector.

Function Output Ground (24B)

Use this connector for the return circuit for the function output.

Input Monitor (24A)

This terminal is in parallel with the front panel INPUT MONITOR connector.

Input Monitor Ground (23A)

Use this connector as the return circuit for the INPUT MONITOR.

Converter Output (20A)

This connector provides a dc output from the ac to dc converter. This level corresponds to the average or rms output as selected on the front panel. The output level is 1 V, + 5 % for a 1000 count display. The source resistance is 500 Ω, ±5 %.

dB Converter Output (19B)

This connector provides a dc output from the logarithmic dB convener. The output voltage is 10 mV, ±5 % for each 1 dB on the display. The source resistance is 1 k Ω, ±5 %. Changes in input level range or distortion range will cause brief ac transients.

dB Converter Output Ground (20B)

Use this connector as the ground return for the dB converter output.

REAR INTERFACE GPIB CONNECTOR
GPIB BOARD (A14)

FUNCTION	PIN		PIN	FUNCTION
D101	1		2	D105
D102	3		4	D106
D103	5		6	D107
D104	7		8	D108
	9		10	
EOI	11		12	IFC
DAV	13		14	SRQ
MRFD	15		16	ATN
NDAC	17		18	REN
	19		20	

CEOJR080

DISTORTION ANALYZER REAR VIEW

Fig. 5-3. Rear interface connector assignments.

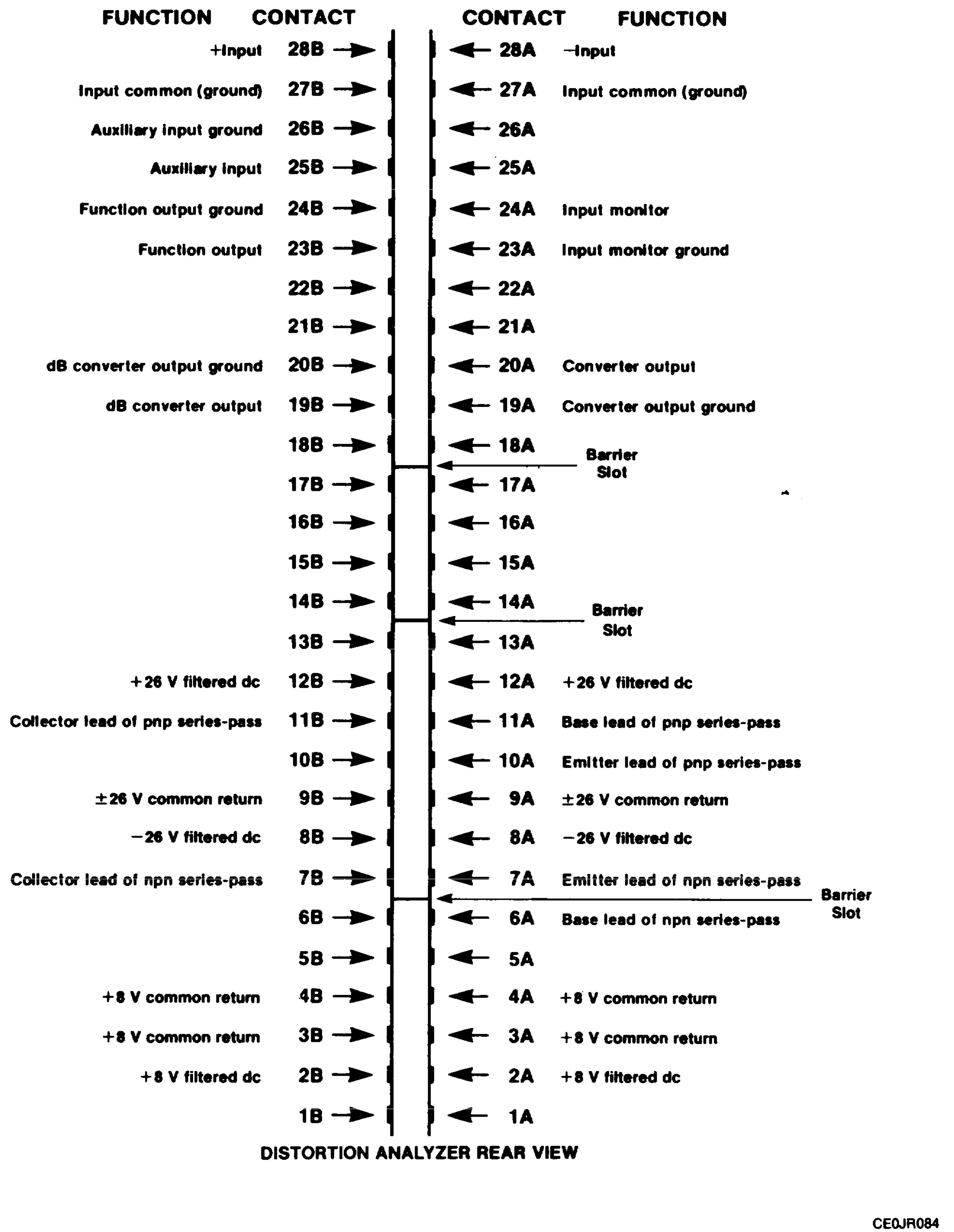


Fig. 5-4. Main board rear interface connector assignment.

GENERAL MAINTENANCE INFORMATION

Troubleshooting Aids

Diagrams. Circuit diagrams are located in the pullout pages of this manual. The portions of the circuit mounted on the circuit boards is enclosed by a solid line. The circuit number of each component in this instrument is shown on a diagram.

Circuit Board Illustrations. Circuit board illustrations are provided in conjunction with the circuit diagrams.

Calibration Fixtures

Several calibration fixtures are available that are helpful in troubleshooting the TS-4084/G.

Service Kit
Analyzer Extender Cable
GPIB Extender Cable

Troubleshooting Equipment

Before using any test equipment to make measurements on static-sensitive components or assemblies, be certain that any voltage or current supplied by the test equipment does not exceed the limits of the component to be tested.

Static-Sensitive Components

CAUTION

Static discharge can damage any semiconductor component in this instrument.

This instrument contains electrical components that are susceptible to damage from static discharge. See Table 5-2 for relative susceptibility of various classes of semiconductors. Static voltages of 1 kV to 30 kV are common in unprotected environments.

Observe the following precautions to avoid damage:

1. Minimize handling of static-sensitive components.
2. Transport and store static-sensitive components or assemblies in their original containers, on a metal rail, or on conductive foam. Label any package that contains static-sensitive assemblies or components.
3. Discharge the static voltage from your body by wearing a wrist strap while handling these components. Servicing static-sensitive assemblies or components should be performed only at a static-free work station by qualified service personnel.
4. Nothing capable of generating or holding a static charge should be allowed on the work station surface.
5. Keep the component leads shorted together whenever possible.
6. Pick up components by the body, never by the leads.
7. Do not slide the components over any surface.
8. Avoid handling components in areas that have a floor *or* work surface covering capable of generating a static charge.
9. Use a soldering iron that is connected to earth ground.
10. Use only special antistatic suction type or wick type desoldering tools.

Table 5-2
RELATIVE SUSCEPTIBILITY TO
STATIC DISCHARGE DAMAGE

Semiconductor Classes	Relative Susceptibility Levels[1]
MOS or CMOS microcircuits or discretes, or linear microcircuits with MOS inputs. (Most Sensitive)	1
ECL	2
Schottky signal diodes	3
Schottky TTL	4
High-frequency bipolar transistors	5
JFETs	6
Linear microcircuits	7
Low-power Schottky TTL	8
TTL (Least Sensitive)	9

[1]Voltage equivalent for levels:

1 = 100 to 500 V　　4 = 500 V　　7 = 400 to low V (est.)
2 = 200 to 600 V　　5 = 400 to 600 V　　8 = 300 V
3 = 250 V　　6 = 600 to 800 V　　9 = 1200 V
(Voltage discharged from a 100 pF capacitor through a resistance of 100 Ω.)

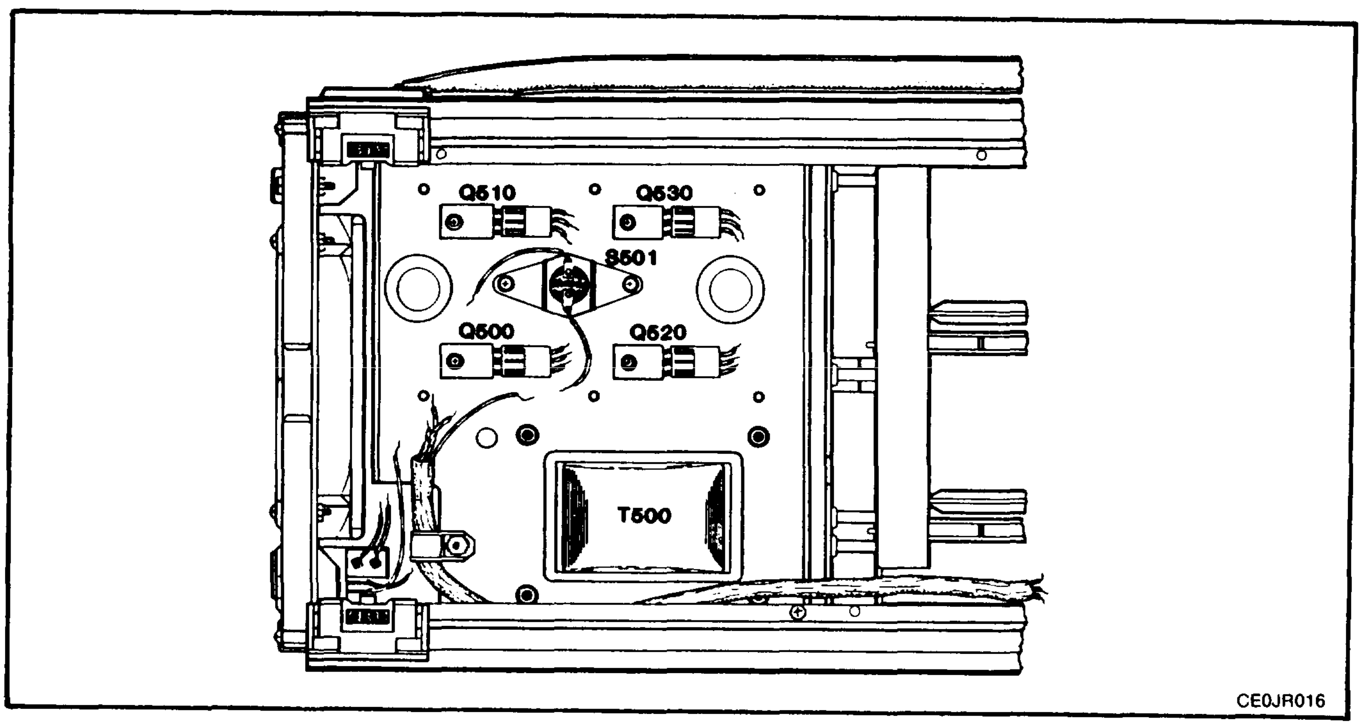


Fig. 5-5. Main power supply (bottom view).

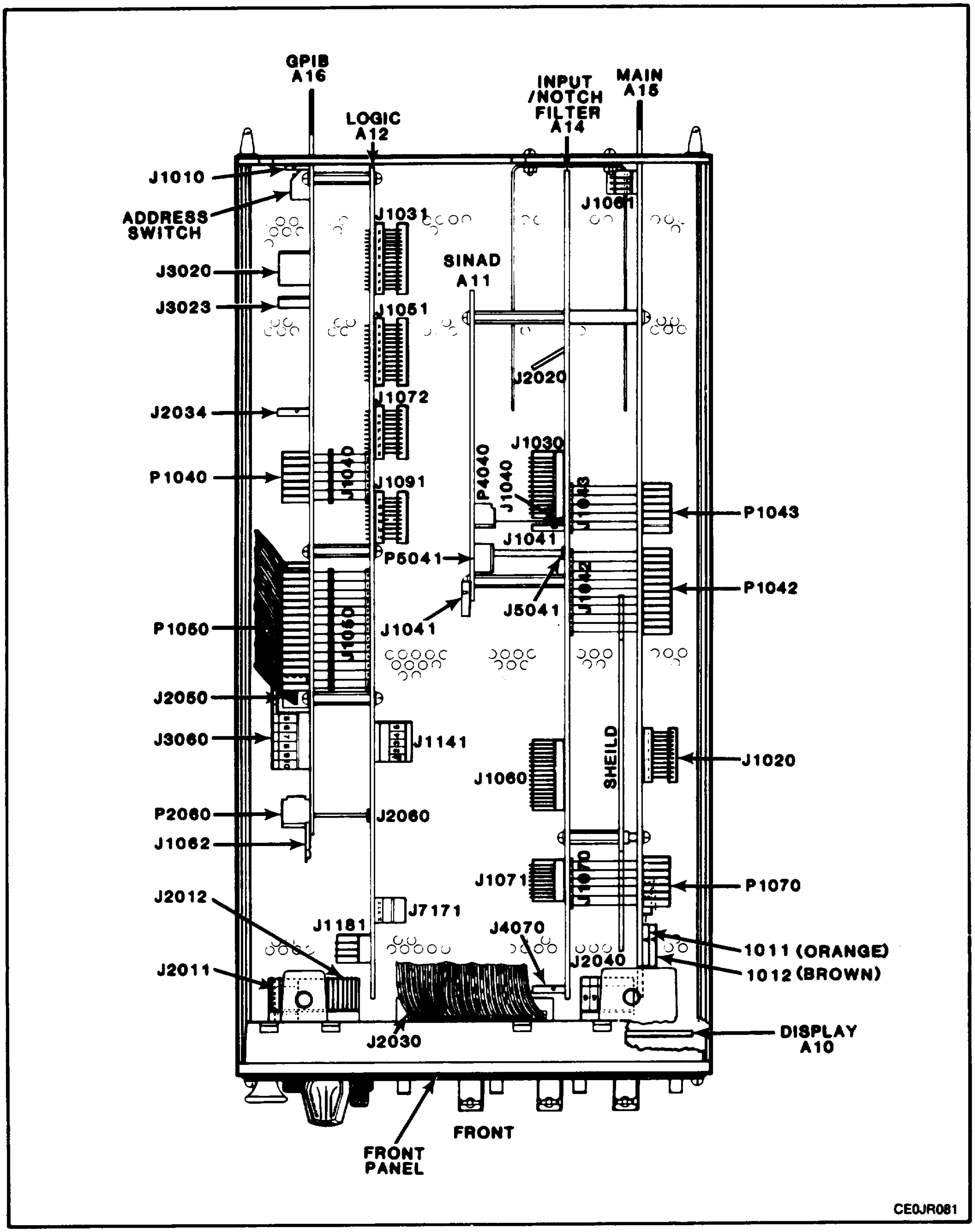


Fig. 5-6. Circuit boards and connectors pictorial (top view).

DISASSEMBLY

This section of the manual describes removing the distortion anatyzer from the power supply and removal of distortion analyzer circuit boards.

DISTORTION ANALYZER REMOVAL

To remove the distortion analyzer from the power supply, follow the procedure described below.

CAUTION

To prevent damage to the distoration *analyzer, turn off the power supply before installing or removing the distortion analyzer. Do* not use *excessive force to install or remove.*

1. Remove the three retainer blocks on the lower, front edge of the TS-4084/G, using a Torx-Head screwdriver.

2. To remove the distortion analyzer from the power supply, pull out on the release latch (located in the lower left comer of the front panel), until the interconnecting jacks disengage and the distortion analyzer slides out.

CIRCUIT BOARD REMOVAL

Refer to the following procedure and Fig. 5-6 for circuit board location.

1. Top Cover Removal

a. Remove the two side covers (four 1/4 turn fasteners).

b. Remove the top cover screws (2).

c. Remove screws (2) attaching the back cover to top cover.

d. Carefully pull the top cover up to remove.

2. Bottom and Back Covers Removal

a. Remove top rover.

b. Remove shield ground screw (1) on bottom.

c. Remove the latch assembly using the following procedure. Refer to Fig. 5-7.

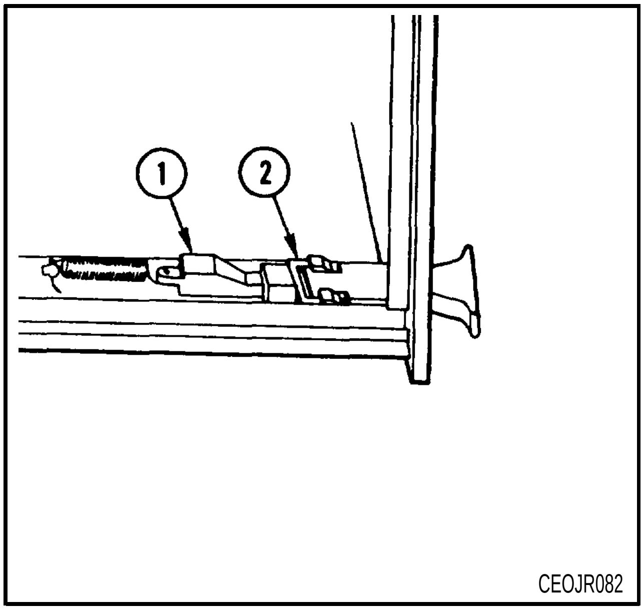


Fig. 5-7. Latch assembly pictorial.

Use a small screwdriver to push forward slightly on the rear latch just in front of the spring. Press down on the latch knob to raise the latch knob extension at the point where the two latch pieces engage. While holding the latch knob down, push upon the front panel latch piece at the point of engagement to disengage the two pieces. Then, pull the latch knob out.

CAUTION

Do not install the distortion analyzer in the power supply while the latch is disassembled. Removal of the distortion analyzer without use of the latch can be extremely difficult.

d. Remove screws (2) attaching the bottom cover to front panel.

CAUTION

The spacers used on the front panel screws are necessary to prevent damage to the front panel. Make sure these spacers are in place when the screws are reinstalled.

e. Carefully pull the covers down and back to remove.

NOTE

For proper orientation, match triangle on connectors to triangle on circuit boards.

3. Main (A15), Input/Notch (A14), and SINAD (A11) Boards Removal

a. Remove the top, bottom and back covers.

b. Remove the Cable Assembly from J1020 on the Main Board

c. Position the distortion analyzer bottom side up, and remove the cable from J7171 on the Logic Board and J4070 on the Input/Notch Board.

d. Remove the screws (2) that secure the Main Board to the Front panel.

e. Slide the boards back to disengage the pushbutton switches from the front panel and fold out the boards as an assembly.

NOTE

This position may be used for troubleshooting most of the distortion analyzer with an input singal applied to J4070 on the Input/Notoh Board. If further disassembly is required, continue this procedure.

f. Remove the screws (3) that secure the SINAD Board. Disconnect the cable from J1041 on the SINAD Board and carefully pull up the board to separate.

g. Disconnect all cables attaching the board assembly to the rest of the instrument.

h. Remove the screws (2) and posts (2) on the Input/Notch Board that secure the Input/Notoh Board to the Main Board and carefully pull the boards apart.

NOTE

On reassembly, the shield should be secured to the Main Board by the screws (3) before the spacers (2) are added.

4. Control Logic (A12) and GPIB (A16) Boards Removal

a. Remove the top, bottom and back covers.

b. Carefully unsolder resistors (2) R530 and R540 from the Input connector solder lugs.

c. Remove the Input Range knob.

d. Disconnect all ribbon cables from the Control Logic and GPIB Boards.

e. Remove the screw (1) that secures the Control Logic Board to the Front Panel.

f. Slide the boards back to disengage the pushbutton switches from the front panel.

g. Remove the screws (5) on the GPIB Board that secure the GPIB Board to the Control Logic Board and carefully pull the boards apart.

5. Display Board (A10) Removal

a. Remove the top, bottom and back covers.

b. Remove the Main (A15), Input/Notch (A14), and SINAD (A11) Boards.

c. Remove the Control Logic (A12) and GPIB (A16) Boards.

d. Disconnect all ribbon cables from the Display Board.

e. Remove the screws (2) that secure the Display Board to the Front Panel.

f. Pull the Display Board away from the Front Panel.

Magnetic Shield

The shield attached to the rear plate of the distortion analyzer is heat treated to enhance its magnetic shielding properties. The benefits of this treatment will be destroyed by mechanical stresses applied to this part. As such, care should be taken not to drop or mechanically deform or bend this shield during service operations. Also, this shield uses a single point ground (center mounting screw) to prevent ground loop currents that would decrease its effectiveness. Note that the top and bottom mounting screws use insulating washers.

Soldering Techniques

WARNING

To avoid electric-shock hazard, disconnect the instrument from the power source before soldering.

The reliability and accuracy of this instrument can be maintained only if proper soldering techniques are used when repairing or replacing parts. General soldering techniques which apply to maintenance of any precision electronic equipment should be used when working on this instrument. Use only 60/40 rosin-core, electronic grade solder. The choice of soldering iron is determined by the repair to be made.

CAUTION

Some of the circuit boards in the distortion analyzer are of the multilayer type with conductive paths laminated between the top and bottom board layers. All soldering on these boards should be done with extreme care to prevent breaking the connections to these conductive paths. Only experienced maintenance personnel should attempt to repair these boards. Do not allow solder or solder flux to flow under printed curcuit board switches. The printed circuit board is part of the switch contacts; intermittent switch operation can occur if the contacts are contaminated.

When soldering on circuit boards or small wiring, use only a 15 watt, pencil type soldering iron. A higher wattage soldering iron can cause the etched circuit wiring to separate from the board base material and melt the insulation from small wiring. Always keep the soldering iron tip properly tinned to ensure the best head transfer to the solder joint. Apply only enough heat to remove the component or to make a good solder joint. To protect heat sensitive components, hold the component lead with a pair of long-nose pliers between the component body and the solder joint.

Use a solder removing wick to remove excess solder from connections or to clean circuit board pads.

Coaxial Cables

If the coaxial cable to the FUNCTION OUTPUT front panel connector is damaged, replace the entire cable assembly. Other coaxial cables in the distortion analyzer can be replaced or repaired as necessary.

Exterior Cleaning

Chassis. Accumulated dust on the instrument chassis can be removed with a soft cloth or small brush. Remove dirt that remains with a soft cloth dampened in a mild detergent and water solution; then remove the detergent with a cloth dampened in clean water. Do not use abrasive cleaners.

Front Panel. Use only a cotton swab or soft cloth, dampened in isopropyl alcohol or water.

CAUTION

To avoid damage, use only isopropyl alcohol or water. Do not use petroleum based cleansing agents.

Interior Cleaning

Clean circuit boards only when required for operation to specified performance. Dust in the interior of the instrument should be removed occasionally due to its electrical conductivity under high humidity conditions.

The best way to clean the interior is to blow off the accumulated dust with dry, low-velocity air (approximately 5 lb/in^2. Then use a soft brush.

Do not scrape or use an eraser to clean the edge connector contacts. Abrasive cleaning can remove the gold plating.

GPIB ADDRESS AND MESSAGE TERMINATOR SWITCHES

Setting the GPIB Address Switches

A single bank of six switches is located on the GPIB circuit board and is accessable through the rear panel. See Fig. 5-8. Five of these switches (A5 through A1) set the desired value of the lower five bits of the listen and talk addresses for the TS-4084/G. The decimal value of these switches is called the instrument's primary address which corresponds to the listen and talk addresses. See Table 5-3.

The TS-4084/G microprocessor reads these switches only at each power-up event.

The address byte sent by the controller is actually eight bits wide. Bits 5 through 1 are for the primary address set according to Table 5-3, while bits 7 and 6 determine whether the byte is a listen address (32 + primary address) or a talk address (64 + primary address). Secondary address bytes (where bits 7 and 6 are both logical 1) are not used by the TS-4084/G, so they are ignored.

Before power-up, set switches A1 through A5 (see Table 5-3) as desired. Do not set primary address 0 when using TEKTRONIX 4050-Series controllers. They reserve primary address 0 for themselves. Setting the primary address to 31 logically removes the TS-4084/G from the GPIB. It does not respond to any GPIB addresses or commands and remains both unlistened (UNL) and untalked (UNT).

The TS-4084/G is factory set to primary address 28 and EOI ONLY.

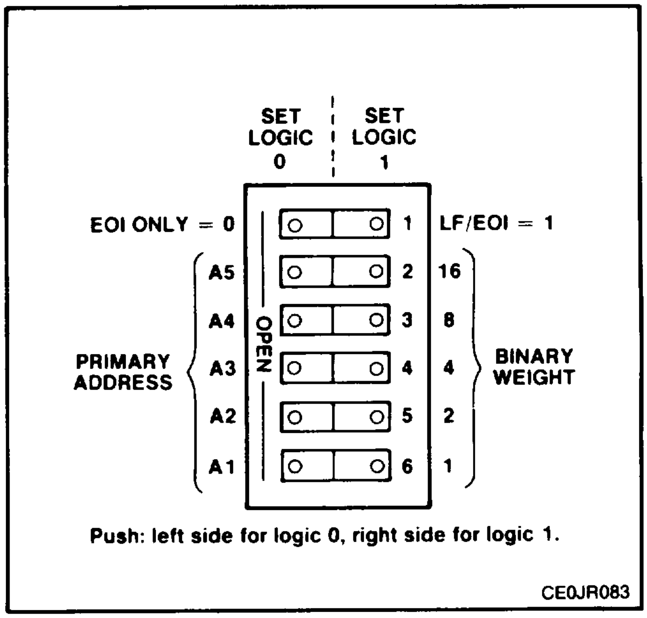


Fig. 5-8. GPIB address and message terminator switches.

Table 5-3
IEEE 488 (GPIB)
PRIMARY ADDRESSES

Switches					
A5	A4	A3	A2	A1	Primary Address
0	0	0	0	0	0
0	0	0	0	1	1
0	0	0	1	0	2
0	0	0	1	1	3
0	0	1	0	0	4
0	0	1	0	1	5
0	0	1	1	0	6
0	0	1	1	1	7
0	1	0	0	0	8
0	1	0	0	1	9
0	1	0	1	0	10
0	1	0	1	1	11
0	1	1	0	0	12
0	1	1	0	1	13
0	1	1	1	0	14
0	1	1	1	1	15
1	0	0	0	0	16
1	0	0	0	1	17
1	0	0	1	0	18
1	0	0	1	1	19
1	0	1	0	0	20
1	0	1	0	1	21
1	0	1	1	0	22
1	0	1	1	1	23
1	1	0	0	0	24
1	1	0	0	1	25
1	1	0	1	0	26
1	1	0	1	1	27
1	1	1	0	0	28
1	1	1	0	1	29
1	1	1	1	0	30
1	1	1	1	1	31

Setting the Message Terminator Switch

The top switch (number 1), illustrated in Fig 5-7, is used to select the terminator of both input and output messages on the GPIB.

With EOI ONLY selected as the terminator, the instrument interprets a data byte received with EOI asserted as the end of an input message string. It also asserts EOI concurrently with the last byte of an output message.

With LF/EOl selected as the terminator, the instrument interprets the line feed (LF) character or the assertion of EOI Concurrently with a data byte as the end of an input message. The TS-4084/G also transmits the carriage return (CR) and line feed (LF), with EOI asserted along with LF, to terminate output messages.

The TS-4084/G is factory set to primary address 28 and EOI ONLY.

TROUBLESHOOTING INFORMATION

Introduction

Troubleshooting information for the TS-4084/G includes hardware tests, and troubleshooting tables for selected digital circuits.

If an error code is returned to the controller in response to an ERR? query, refer to the error code definitions in the Programming section of this manual. The only error codes that indicate instrument malfunction are those classified as Internal Errors in the error code list.

HARDWARE TESTS

The hardware is tested by the TS-4084/G firmware in two ways:

- Power-on Self Tests
- Test Query

Power-On Self Test

The power-on self tests run each hardware test once. If an error occurs, the TS-4084/G front panel display is set to the code of the first error detected. The TS-4084/G will not perform any other functions if an error has occurred.

The tests performed and their corresponding error displays are listed in Table 5-4.

Table 5-4
FRONT PANEL ERROR DISPLAY
POWER-ON SELF TESTS

ERROR	DISPLAY LEDS			
	UNL	ADRS	dBm	dB
Bad RAM (high nibble) U3043	OFF	ON	FLASHING	FLASHING
Bad RAM (low nibble) U3034	OFF	OFF	FLASHING	FLASHING
Bad ROM U4030	ON	OFF	FLASHING	FLASHING

The Test Query

The second test method is the TEST? (TEST query). This performs only the ROM test. TEST? is sent to the TS-4084/G over the GPIB. When received, the TS-4084/G will:

1. Save the current state of the machine.

2. Perform the ROM test.

3. Reports the error, if any, in the form:

   TEST 394;

   If no errors are detected, the response is:

   TEST 0;

4. The TS-4084/G is returned to its settings prior to the TEST? execution.

Troubleshooting High Residual Distortion Problems

Because of the ultra-low distortion and noise levels in the TS-4084/G, the following precautions and suggestions will save considerable time and minimize erroneous diagnoses.

1. Use only the recommended SG 505 oscillator as a signal source. A TS-4084/G residual distortion reading will include the effects of noise and distortion contributions from both oscillator and analyzer. Using other oscillators may give inferior results.

2. Perform servicing only in a "quiet" environment, free from excessive electromagnetic ‘interference. Without its shielding, a disassembled TS-4084/G is susceptible to stray fields from power transformers, flourescent lights, and particularly raster-scan monitors. Monitors of this type should be turned off, or located at least 5 meters away during troubleshooting.

3. Avoid the use of general purpose bnc connector terminators. Many terminators have voltage coefficients that cause excessive distortion, compared to that of the TS-4084/G.

4. Connect an oscilloscope system to the FUNCTION OUTPUT, for observation of the residual products actually being measured. Some problems, with high residual readings do not involve distortion but are caused by excessive noise or incomplete fundamental nulling.

Sightly high (or just marginal) residual distortion performance is usually caused by a degradation of a single component in the main signal path.

Semi-conductor devices should be investigated first in the following order of probability: LDRs (light dependent resistors), op-amps (operational amplifiers), and transistors or diodes.

During disassembly, repair, and reassembly, use good static control measures. Even small static discharges can induce soft failures in the LDRs or op-amps resulting in substantially higher distortion or noise contribution.

Also, exercise care when soldering LDRs and op-amps to minimize the chance of heat damage, which can have a similar degrading effect.

Unusually high residual distortion readings (0.1% to 100%) are often the result of band or range selection malfunctions. Check the appropriate relays, as suggested by the symptoms first. Other possible causes may be found in the band discriminator or ranging logic circuitry.

Table 5-5
CABLE DESTINATION LISTING

CABLE #	FROM	TO
W500	A12J1031	A14J1060
W501	+33 V on A20	A30
W502	–33 V on A20	A30
W503	Ground on A20	A30
W504	A20	Q500 and Q510
W505	A30	Q520 and Q530
W510	A10J2040	A12J1072
W520	A12J1091	A15J1011
W524	S501 (Thermal Cut-Out)	A500 (line voltage selection assembly)
W525	Power Switch	Cable
W523	Line Filter (A35)	Chassis Ground
W530	A10J2011	A12J1181
W550	A12J1141	A14J1071
W560	A12J7171	A15J1061
W570	A10J2012	A16J3060
W580	A10J2030	A16J2050
W585	A15J1012	A16J2034
W590	A15J1020	J500, J510, J520
W600	A12J1051	A14J1030
W610	A11J1041	A14J2020, Back of A15
	A16J1062	Back of A15
W700	A33J1110	A30 (GPIB Interconnect)

T R O U B L E S H O O T I N G

MAIN POWER SUPPLY

Troubleshoot using the Main Power Supply schematic (Fig. FO-14).

NOTE

Repair of Main Power Supply is limited to replacement of F500 Input Fuse, A35 Line Voltage Selector Assembly, Voltage Selector Circuit Board, S501 Thermistor Switch, S500 Power Switch, T500 Transformer, Q500, Q510, Q520, Q530 and A20 Power Supply Board.

A15 MAIN BOARD POWER SUPPLY

Troubleshoot using the A15 Main Board Layout (Fig. FO-10) and the A15 Power supply schematic (Fig. FO-11).

NOTE

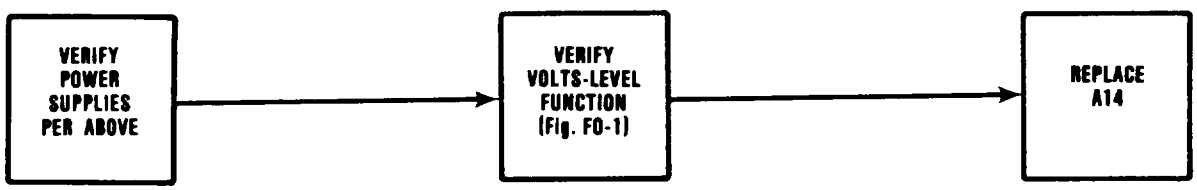
Repair of the A 15 Main Board Power Supply is limited to the replacement of fuses F4060, F4061 and F4062.

If the power supply voltages are low or missing, systematically lift each circuit board until the one loading down the power supply is isolated.

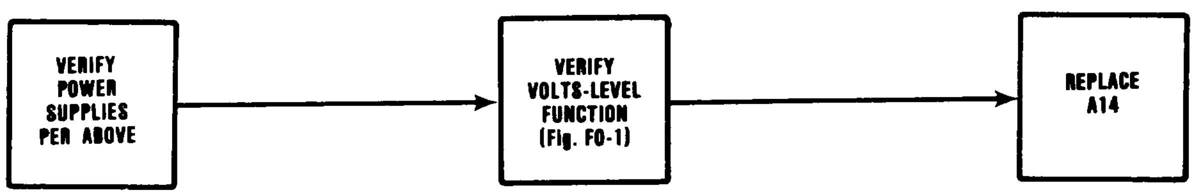
The following information is intended to be used to troubleshoot and repair the TS-4084/G down to circuit board level. Section I refers to specific troubleshooting steps necessary when a problem is found during the instrument performance checks. Section II lists several symptoms and the troubleshooting steps necessary to isolate the problem to a specific circuit board.

TROUBLESHOOTING GUIDE — PART I

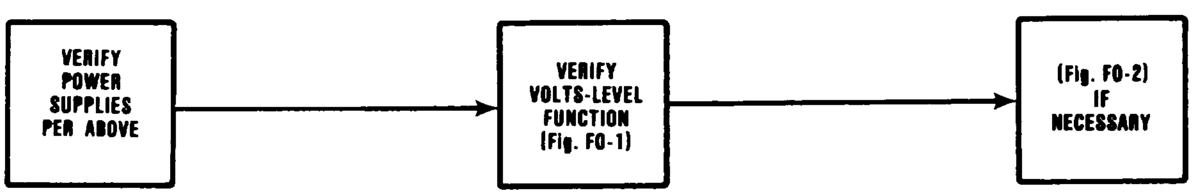
1 **Performance Check Step #1** — Input Impedance
Problem: Input impedance measures out of specification.



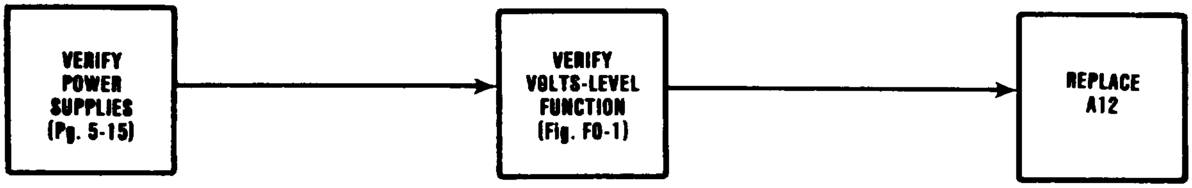
2 **Performance Check Step #2** — Common Mode Rejection
Problem: Common mode rejection out of specification.



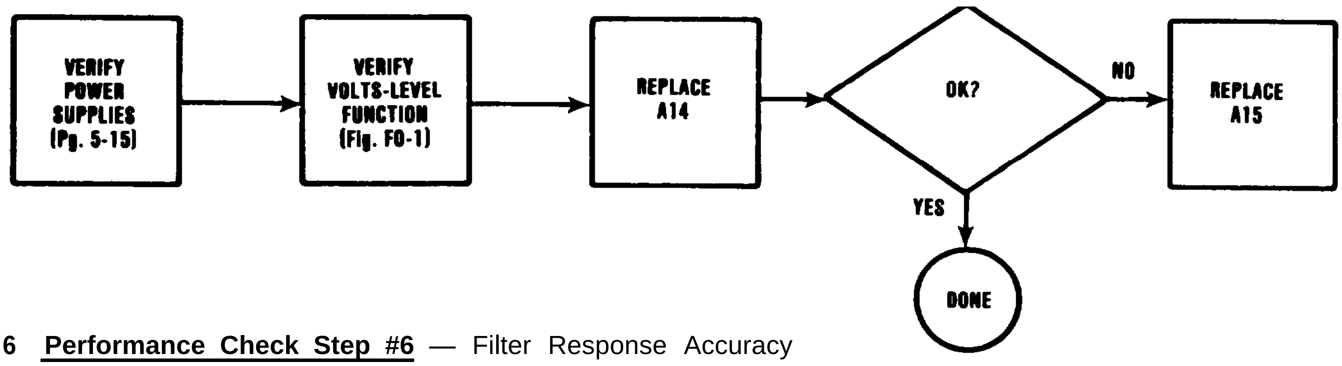
3 **Performance Check Step #3** — Volts Accuracy
Problem: Volts accuracy out of specification.



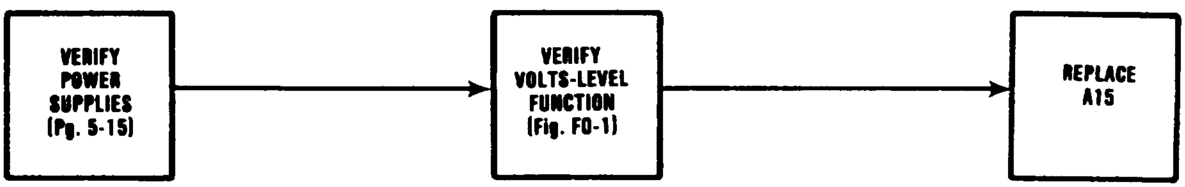
4 **Performance Check Stip #4** — dBm Accuracy and Flatness
Problem: dBm accuracy and flatness out of specification.



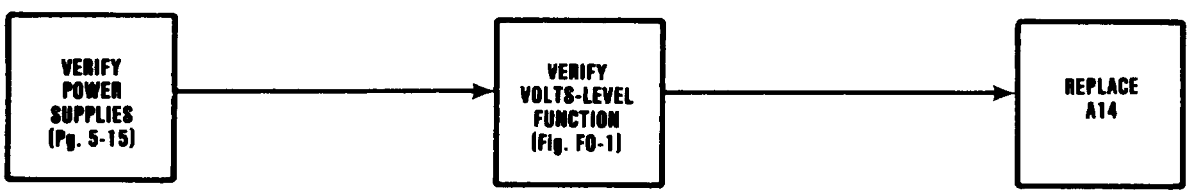
5 **Performance Check Step #5** — Bandwidth
Problem: Bandwidth out of specification.



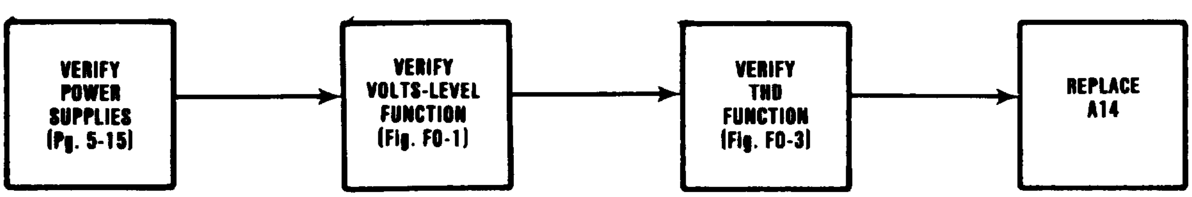
6 **Performance Check Step #6** — Filter Response Accuracy
Problem: Filter response out of specification.



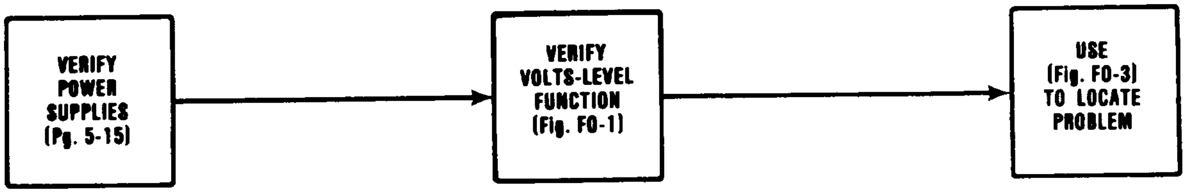
7 **Performance Check Step #7** — Residual Noise
Problem: Residual noise out of specification.



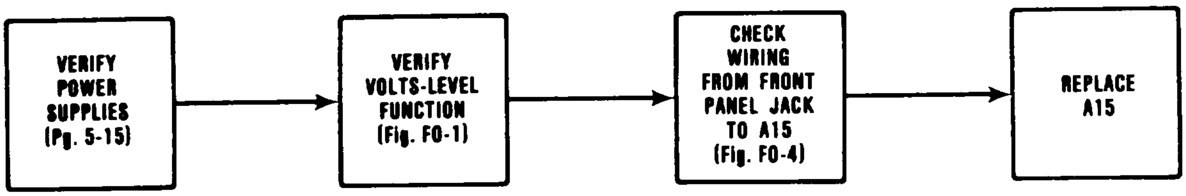
8 **Performance Check Step #8** — Total Harmonic Distortion Accuracy
Problem: Total harmonic distortion accuracy out of specification.



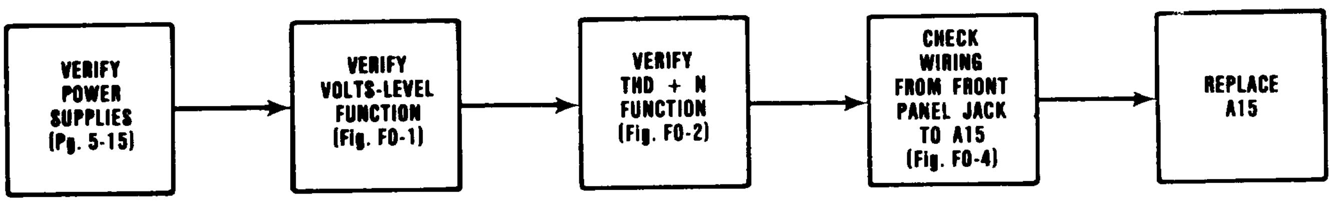
9 **Performance Check Step #9** – Residual THD + N
Problem: Residual THD + N out of specification.



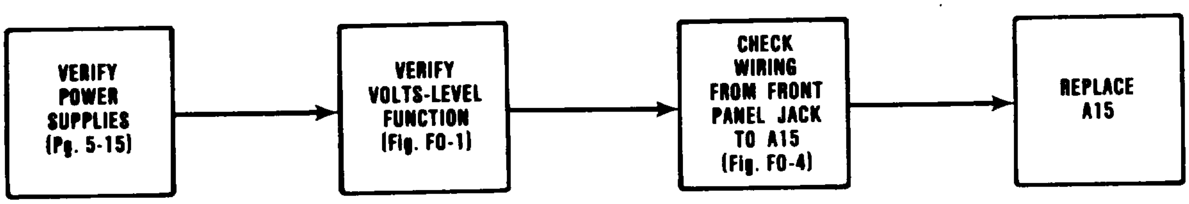
10 **Performance Check Step #10** – Input Monitor
Problem: Input monitor will not meet specifications.



11 **Performance Check Step #11** — Function Out
Problem: Function out will not meet specifications.



12 **Performance Check Step #12** — Auxiliary Input
Problem: Auxiliary input will not meet specifications.

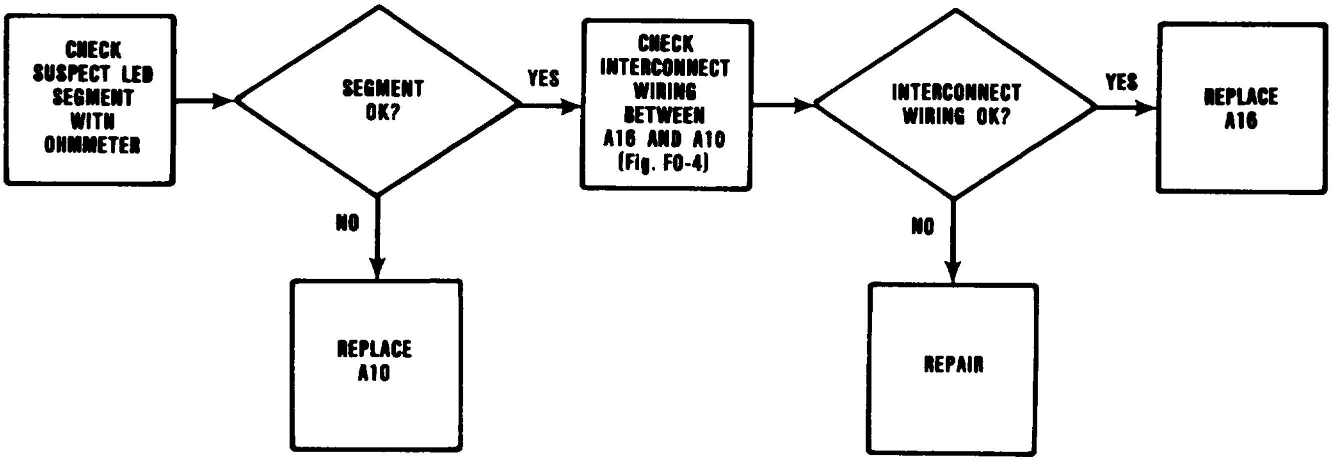


13 **Performance Cheek Step #13** — GPIB Operation
Problem: Incorrect GPIB operation.

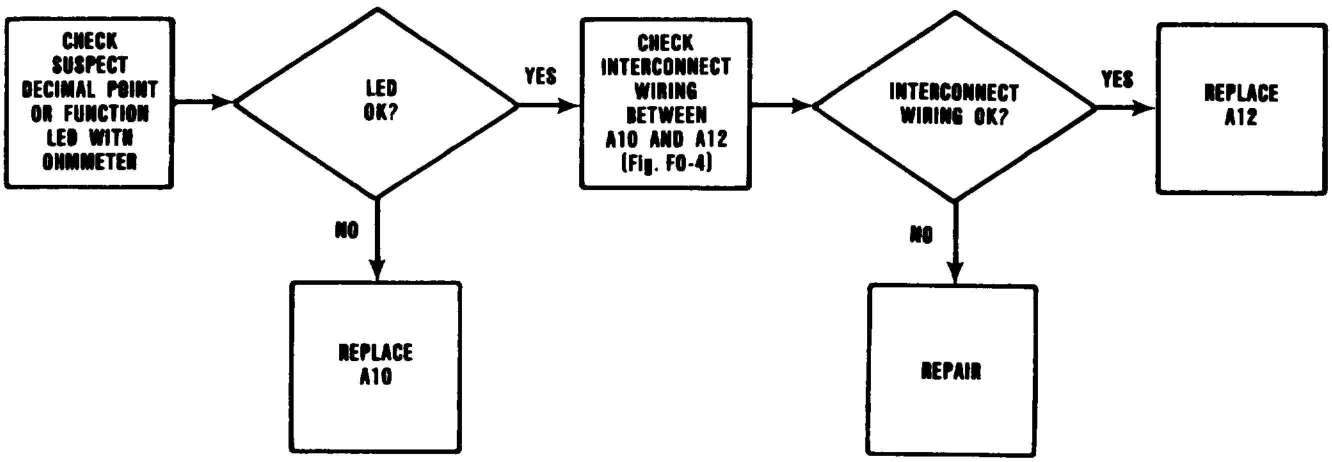
TROUBLESHOOTING GUIDE — PART II

Display Problems:

Symptom — Bar Graph or digit segment will not light.

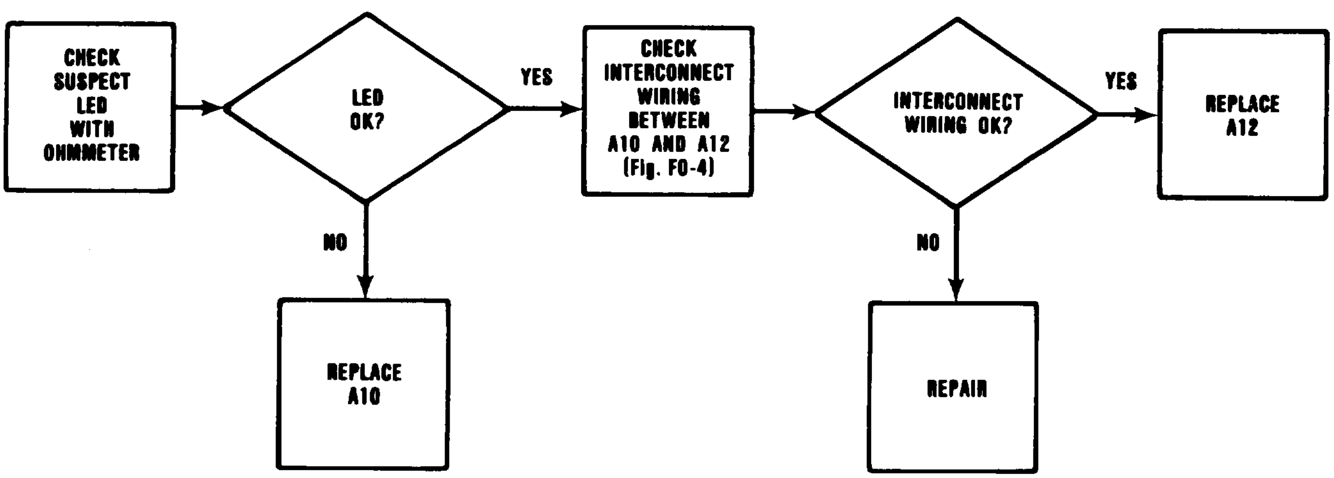


Symptom — Decimal points or function indicators will not light or wrong logic (i.e. more than one decimal point or function light).

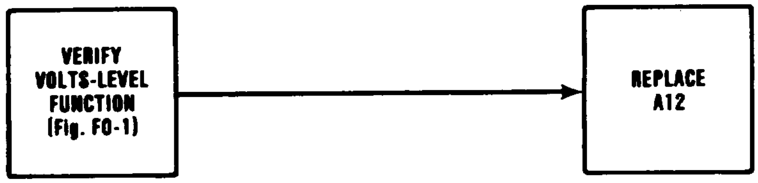


Input Auto Range and Increase-Decrease Range Indicators:

Symptom — Increase or Decrease Range indicator will not light.

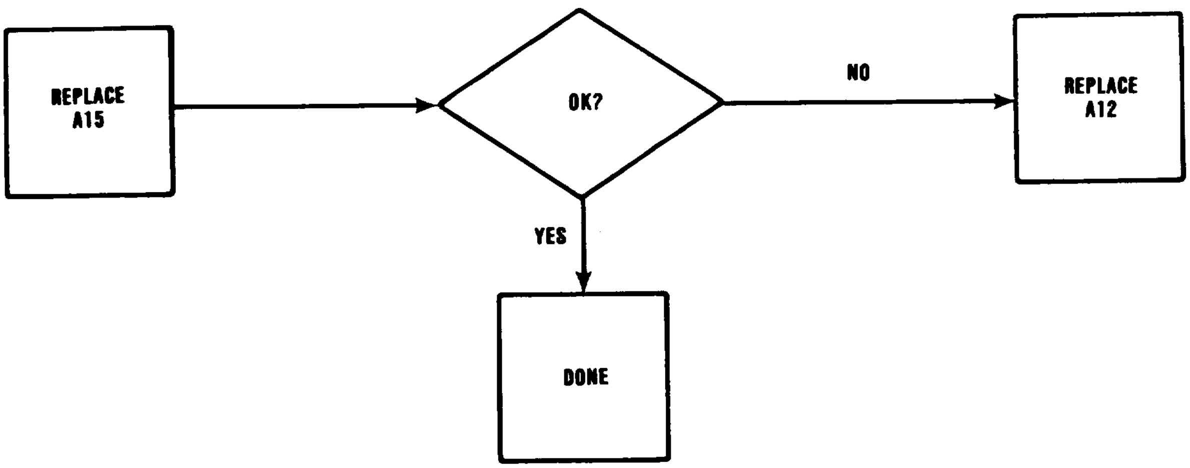


Symptom — Will not auto-range to correct input range-incorrect operation of increase-decrease range lights.



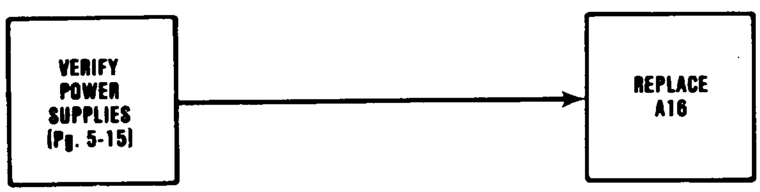
Distortion Auto-Ranging:

Symptom – Distortion Auto-Ranging will not work. (i.e. will not select correct range or manual ranging is inoperative.)



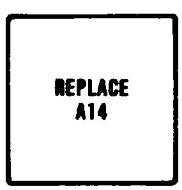
Power-up Self Test:

Symptom — Instrument displays a self-test error on power-up.



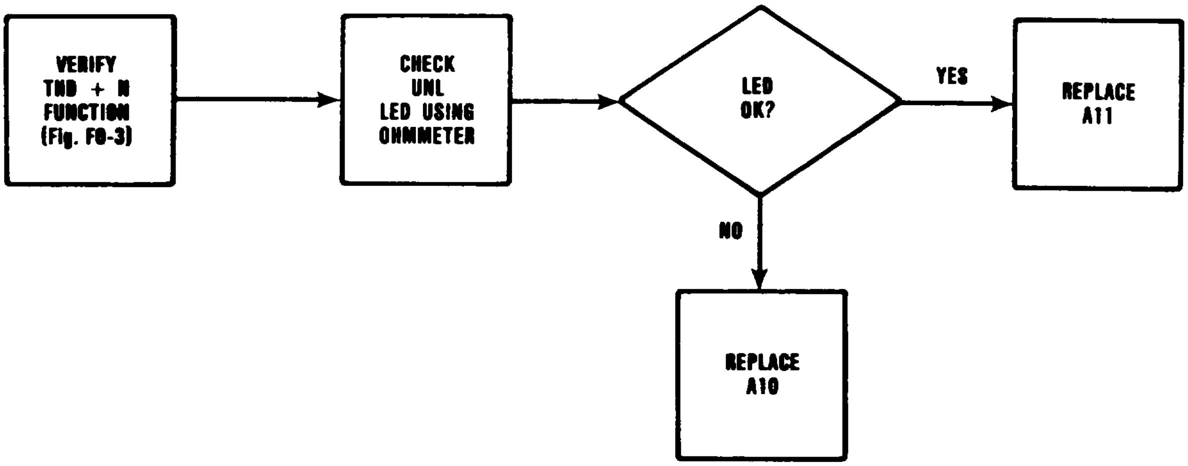
High Frequency Compensation:

Symptom — High Frequency Compensation won't adjust correctly.



Unlock Indicator:

Symptom — Unlock indicator does not give correct indication.



dB Functions:

Symptom — dBm, dB Ratio, SINAD, or THD dB problems.

Section 6

PROGRAMMING

Introduction

This section of the manual provides information for programming the TS-4084/G 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[1]. The TS-4084/G is 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.

Instrument commands are presented in three formats:

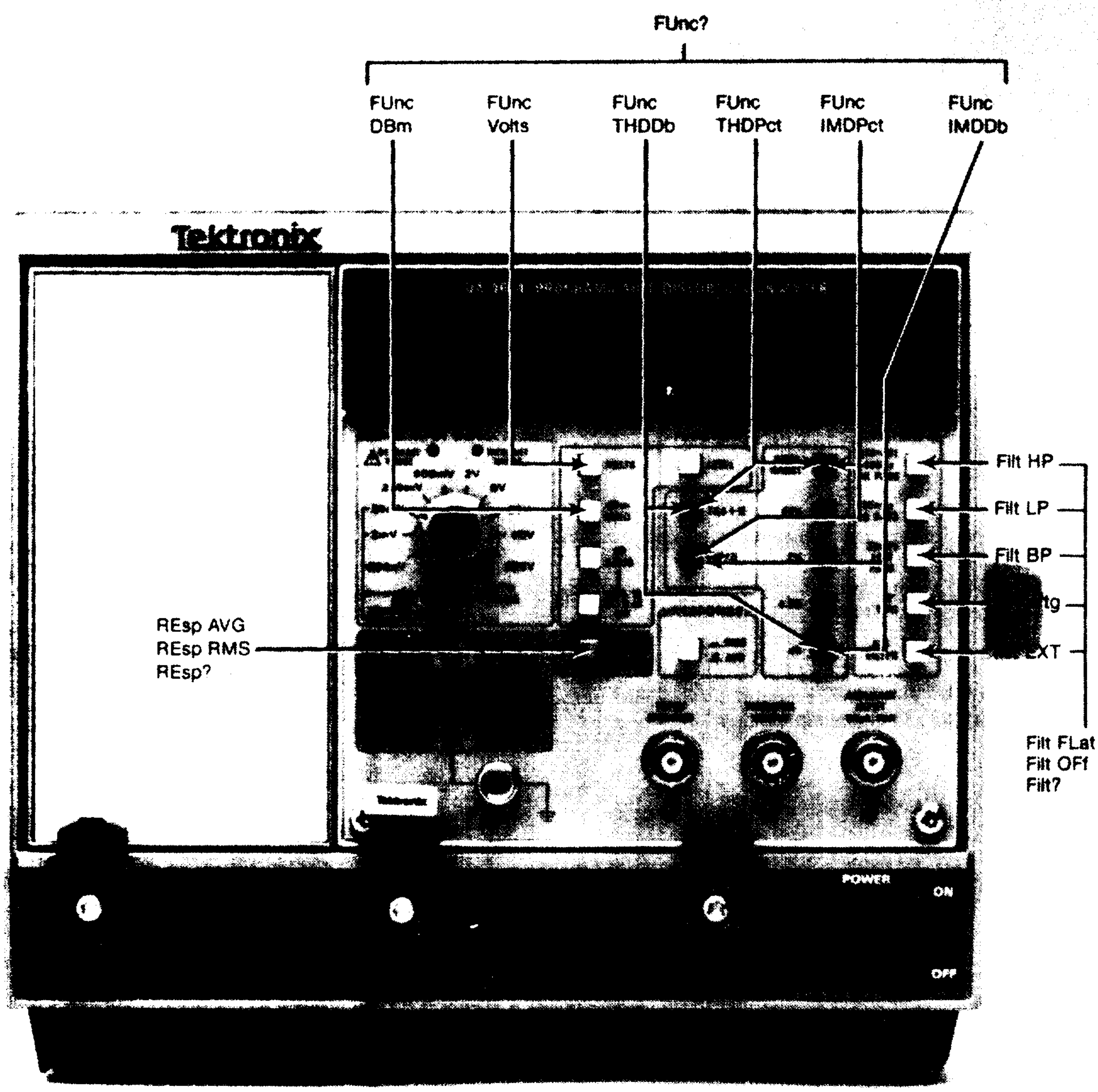
- **A front panel illustration** — showing command relationships to front panel operation. See Fig. 6-1.
- **Instrument Commend List** — A list divided into functional groups with brief descriptions.
- **Detailed Command List** — An alphabetical listing of commands with complete descriptions.

The TS-4084/G instrument connects to the GPIB through a connector on the rear of the power module. Review this section to become familiar with front-panel and internally selectable instrument functions.

GPIB Address and Terminator Setting

The GPIB primary address for this instrument is set on the rear panel of the Distortion Analyzer Module. The TS-4084/G 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). The TS-4084/G is shipped with this terminator set to EOI ONLY. Refer to the Maintenance section of this manual for locations and setting information.

[1]Pubiishod by the institute of Electrical and Electronics Engineers, Inc., 345 East 47th Street, NEw York, NY, 10017



General

Counts	FPset	OPc ON	RQs ON
Counts?		OPcOFF	RQs OFF
	Help	OPc?	RQs?
DUs ON		OVer ON	
DUs OFF	ID?	OVer OFF	SENd
DUs?	INit	OVer?	SET?
ERRMsg		Points <num>	TEst
ERR?		Points?	TOI <num>
EVent?			TOI?

Fig. 6-1. TS-4084/G commands and relationships to front panel controls. See command lists for descriptions.

COMMANDS

The commands for the TS-4084/G 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.

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.

Instrument Commands

Counts <num> — Sets the display counts window for the settling 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 30 KHz low pass filter.

[Filters] EXternal — Enablea external filter.

[Filters] FLat — Disables all filters.

[Filters] HPass — Enables high pass filter.

[Filters] Lpass — Enables 80 KHz low pass filter.

Filters OFf — Disables all fitters.

[Filters] Wtg — Enables weighting filter.

Filters? — Retums the state of all programmable filters.

FPset — Sets to front panel settings while under remote control.

[FUnction] DBm — Selects level measurement in decibels relative to 0.775 volts.

[FUnction] lMDDb — Selects SINAD (the ratio of Signal + Noise + Distortion to Noise + Distortion) measured in decibels.

[FUnction] lMDPct — Selects SINAD (the ratio of Signal + Noise + Distortion to Noise + Distortion) measured in percent.

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

[FUnction] Volts — Selects level measurement in rms volts

FUnction? — Returns the type of measurement selected.

HElp? — Returns a list of command headers.

lDentify? — Returns instrument identification and firmware version.

lNit — 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? — ReWna OVER ON or OVER OFF.

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

Points? — Returns the POINTS setting.

[REsponse] AVG — Selects average response.

[REsponse] AVE — Selects average response.

[REsponse] RMs — Selects rms response.

REsponse? — Retums AVG or RMS response.

RQs [ON] — Enables generation of service requests.

RQs OFf — Disablea generation of service requests.

RQs? — Returns RQS ON or RQS OFF.

SENd — Retums a measurement.

SETtings? — Retums all programmable settings.

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

TOlerance <num> — Sets the tolerance window for the settling algorithm in percent.

Tolerance? — Returns the TOLERANCE setting.

DETAILED COMMAND LIST

NOTE

Brackets [] indiciate the enclosed item is optional, and carets <> indicate a defined element. Capitalized/et-ters are the required characters; the lowercase letters may a/so 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-on initial setting is COUNTS 2.0

DUS (DELAY UNTIL SETTLED)

Type:
Setting or query

Setting Syntax:
DUs [ON]
DUs OFF

Query Syntax:
DUs?

Query Response:
DUS ON; 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-on initial setting is DUS ON.

ERRMSG (ERROR MESSAGE)

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.

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.

EVENT

Type:
Query

Query Syntax:
EVent?

Query Response:
EVENT <numeric>;

Discussion:

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

FILTERS

Type:
Setting or query

Setting Syntax:
[Filters] <argument>
[Filters] <argument>,..., <argument>

Arguments:
BPass
EXternal
FLat
HPass
Lpass
OFf
Wtg

Examples:
Filt Ext
FM HP
FM OFf
BP
FLat
HP ON
HP OFF
Filt Lp,Wtg,Ext

Query Syntax:
Filters?
BPass?
FLat?

Query Response:
FILT BP, EXT, HP;
FILT FLAT;

Discussion:

Each individual command enables the specified filter. FLAT and OFF disables all the 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 power-on initial setting is FLAT.

FPSET (FRONT PANEL SETTINGS)

Type:
Operational

Setting Syntax:
FPset

Discussion:

The FPSET command sets the TS-4084/G 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.

FUNCTION

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?[1]

Query Response:
DBM;
DBR;
IMDDB;
IMDPCT;
THDDB;
THDPCT;
VOLTS;

Discussion

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

IMDDB selects SINAD measurements in decibels.

IMDPCT selects SINAD 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 power-on initial setting is 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,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/DA4084,V81.1,Fx.y;

Discussion:

The IDENTIFY? query returns the above response where:

TEK/DA4084 – Identifies the instrument type.

V81.1 – Identifies the version of Tektronix Codes and Format Standard to which the instrument conforms.

Fx.y – Identify the firmware version of the instrument, where x.y is a decimal number.

INIT (INITIAL SETTINGS)

Type:
Operational

Setting Syntax:
INit

Discussion:

The I NIT command performs a power-on initialization of the instrument's settings. The power-on settings for the TS-40841/G 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 a normal power-on does.

OPC (OPERATION COMPLETE SERVICE REQUEST)

Type:
Setting or Query

Setting Syntax:
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-on initial setting is OPC OFF.

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 m this section.

The power-on initial setting is OVER OFF.

POINTS

Type:
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 withn the setting 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 POINTS? query returns the POINTS setting.

The power-on initial setting is POINTS 3.

RESPONSE

Type:
Setting or query

Setting Syntax:
[REsponse] <argument>

Arguments:
AVErage
AVG
RMs

Examples:
REsp AVE
REsp RMs

Query Syntax:
REsponse?

Query Response:
RESP AVG; or RESP RMS;

Discussion:

The RESPONSE command sets the TS-4084/G for average or rms response.

The RESPONSE query returns the RESPONSE setting.

The RESPONSE header is optional.

The Power-on initial setting is RESPONSE RMS.

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 TS-4084/G.

When RQS is OFF the TS-4084/G will not assert SRQ under any circumstance. When RQS is ON the TS-4084/G 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-on initial setting is RQS ON.

SEND

Type:
Output

Syntex:
SENd

Discussion:

The SEND command returns a measurement. Overrange is 1 E+ 99. New measurements are available as the display updates at approximately three (3) reading/see. Any 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 in this section.

SETTINGS

Type:
Query

Query Syntex:
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 beck to those settings.

TEST (ROM TEST)

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.

TOLERANCE

Type:
Setting or query

Setting Syntax:
TOLerance <numeric>

Arguments:
Any Floating Point Value from O to 100

Examples:
TOL 12
TOL 0.1E+2
TOL 1.5

Query Syntax:
TOlerance?

Query Response:
TOL <numeric>;

Discussion:

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

The TOLERANCE? query returns the TOLERANCE Sewing.

The power-on inital setting is TOLERANCE 2.0.

Settling Algorithm

A settled TS4084/G measurement is obtained by using the SEND command to return a measurement with the SETTLING ALGORITHM previously enabled using the DUS ON command. The Algorithm delays sending the measurement until settling has occurred.

The TS-4084/G 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 O to 100) and the COUNTS command (in display counts from O 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 the settling status. The algorithm is initialized at the time it is enabled (anytime DUS ON is received), or when any setting command is received. Initialization means any collected measurement points are dumped. At least two (2) points will be taken after receiving the SEND command before settled status can occur. The remaining points, if needed, may have been collected before the SEND command was received, if the algorithm was enabled with sufficient time to collect these points. This ensures that the algorithm includes the effects of any system changes that were made near the time the SEND command is received, but returns a measurement sooner if the TS-4084/G remains settled. The measurement returned is the most recent measurement point taken at the time settling occurs.

If settling does not occur within approximately six (6) seconds after the SEND command is received, the TS-4084/G returns the average of it's last six (6) measurement points (approximately 2 seconds, in duration). This averaging allows usable measurements on signals containing low beat frequencies or noise. Additionally, if the OVER is ON, an unsettled SRQ is generated, alerting the controller that averaging has occurred.

Remote Local Exceptions

If the LEVEL, THD+N, SINAD, RESPONSE and any of the filter buttons are pressed, the TS-4084/G returns to local from remote operation.

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. This instrument can be set to accept either 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 TS-4084/G 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. The TS-4084/G is shipped with EOI ONLY selected.

Formatting A Message

Commands sent to the TS-4084/G 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. 6-2.

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, carriage return, and line feed are shown as subscripts in the following examples.

$RQS_{SP}ON$

If extra formatting characters SP, CR, and LF (the LF cannot be used for format in the LF/EOI terminator mode) are added between the header delimiter and the argument, they are ignored by the instrument.

Example 1: $RQS_{SP}ON;$
Example 2: $RQS_{SP\ SP}ON;$
Example 3: $RQS_{SPCR\ LF}$
$_{SP\ SP}ON$

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

$_{sp}RQS_{sp}\ ON;_{CR\ LF}$
$_{SP}DUS_{sp}OFF$

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.

EV
EVe
Even
EVent A?

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

2,3
$2_{sp}3$
$2,_{sp}3$

NOTE

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

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

ASCII AND IEEE 488 (GPIB) CODE CHART

BITS B7 B6 B5 → / B4 B3 B2 B1 ↓	Ø Ø Ø	Ø Ø 1	Ø 1 Ø	Ø 1 1	1 Ø Ø	1 Ø 1	1 1 Ø	1 1 1
	CONTROL		NUMBERS SYMBOLS		UPPER CASE		LOWER	
Ø Ø Ø Ø	0 NUL 0 (0)	20 DLE 10 (16)	40 SP 20 (32)	60 0 30 (48)	100 @ 40 (64)	120 P 50 (80)	140 \` 60 (96)	160 p 70 (112)
Ø Ø Ø 1	1 GTL SOH 1 (1)	21 LLO DC1 11 (17)	41 ! 21 (33)	61 1 31 (49)	101 A 41 (65)	121 Q 51 (81)	141 a 61 (97)	161 q 71 (113)
Ø Ø 1 Ø	2 STX 2 (2)	22 DC2 12 (18)	42 " 22 (34)	62 2 32 (50)	102 B 42 (66)	122 R 52 (82)	142 b 62 (98)	162 r 72 (114)
Ø Ø 1 1	3 ETX 3 (3)	23 DC3 13 (19)	43 # 23 (35)	63 3 33 (51)	103 C 43 (67)	123 S 53 (83)	143 c 63 (99)	163 s 73 (115)
Ø 1 Ø Ø	4 SDC EOT 4 (4)	24 DCL DC4 14 (20)	44 $ 24 (36)	64 4 34 (52)	104 D 44 (68)	124 T 54 (84)	144 d 64 (100)	164 t 74 (116)
Ø 1 Ø 1	5 PPC ENQ 5 (5)	25 PPU NAK 15 (21)	45 % 25 (37)	65 5 35 (53)	105 E 45 (69)	125 U 55 (85)	145 e 65 (101)	165 u 75 (117)
Ø 1 1 Ø	6 ACK 6 (6)	26 SYN 16 (22)	46 & 26 (38)	66 6 36 (54)	106 F 46 (70)	126 V 56 (86)	146 f 66 (102)	166 v 76 (118)
Ø 1 1 1	7 BEL 7 (7)	27 ETB 17 (23)	47 ' 27 (39)	67 7 37 (55)	107 G 47 (71)	127 W 57 (87)	147 g 67 (103)	167 w 77 (119)
1 Ø Ø Ø	10 GET BS 8 (8)	30 SPE CAN 18 (24)	50 (28 (40)	70 8 38 (56)	110 H 48 (72)	130 X 58 (88)	150 h 68 (104)	170 x 78 (120)
1 Ø Ø 1	11 TCT HT 9 (9)	31 SPD EM 19 (25)	51) 29 (41)	71 9 39 (57)	111 I 49 (73)	131 Y 59 (89)	151 i 69 (105)	171 y 79 (121)
1 Ø 1 Ø	12 LF A (10)	32 SUB 1A (26)	52 * 2A (42)	72 : 3A (58)	112 J 4A (74)	132 Z 5A (90)	152 j 6A (106)	172 z 7A (122)
1 Ø 1 1	13 VT B (11)	33 ESC 1B (27)	53 + 2B (43)	73 ; 3B (59)	113 K 4B (75)	133 [5B (91)	153 k 6B (107)	173 { 7B (123)
1 1 Ø Ø	14 FF C (12)	34 FS 1C (28)	54 , 2C (44)	74 < 3C (60)	114 L 4C (76)	134 \ 5C (92)	154 l 6C (108)	174 | 7C (124)
1 1 Ø 1	15 CR D (13)	35 GS 1D (29)	55 – 2D (45)	75 = 3D (61)	115 M 4D (77)	135] 5D (93)	155 m 6D (109)	175 } 7D (125)
1 1 1 Ø	16 SO E (14)	36 RS 1E (30)	56 . 2E (46)	76 > 3E (62)	116 N 4E (78)	136 ^ 5E (94)	156 n 6E (110)	176 ~ 7E (126)
1 1 1 1	17 SI F (15)	37 US 1F (31)	57 / 2F (47)	77 ? UNL 3F (63)	117 O 4F (79)	137 UNT _ 5F (95)	157 o 6F (111)	177 RUBOUT (DEL) 7F (127)

ADDRESSED COMMANDS

UNIVERSAL COMMANDS

LISTEN ADDRESSES

TALK ADDRESSES

SECONDARY ADDRESSES OR COMMANDS

KEY TO CHART

octal — 25 PPU — GPIB code

NAK — ASCII character

hex — 15 (21) — decimal

CE0JR014

Fig. 6-2. ASCII and IEEE 488 (GPIB) code chart.

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 if 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 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 are 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 NRFD) until space is available in the buffer.

When buffer space is available, the instrument accepts a second message before processing the first. However, additional messages are held off with NRFD 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 sendng its message. Because the instruments input buffer is full and the remainder of the controllers message is held off by NRFD, 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.

The TS-4084/G can be made a talker without having received a message that specifies the output. Refer to the SEND command in this section.

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.

Listen	WYBTE @ A:
Unlisten	WYBTE @ 63:
Talk	WYBTE @ B:
Untalk	WYBTE @ 95:
Untalk – unlisten	WYBTE @ 63, 95:
Device clear (DCL)	WYBTE @ 20:
Selective device clear (SDC)	WYBTE @ A, 4:
Go to local (GTL)	WYBTE @ A, 1:
Remote with lockout	WYBTE @ A, 17, 63:
Local lockout of all instruments	WYBTE @ 17:
Group execute trigger (GFT)	WYBTE @ A, 8:

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

UNL—Unlisten
UNT—Untalk

When the TS-4084/G receives the UNL command the listener function goes to the idle state (unaddressed). In the idle state, the TS-4084/G does not accept instrument commands from the GPIB.

The talker function goes to the idle state when the TS-4084/G receives the UNT command. In this state, the TS-4084/G cannot output data via the GPIB.

IFC—Interface Clear

This uniline message has the same affect as both the UNT and UNL messages.

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 TS-4084/G an SRQ is unassorted 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 TS-4084/G recognizes the GET message. Upon receipt the TS-4084/G issues an error.

SPE—Serial Poll Enable
SPD—Serial Poll Disable

The SPE message enables the TS-4084/G to output serial poll status bytes when it is talk addressed. The SPD message switches the TS-4084/G to sending data from the output buffer.

MLA—My Listen Address
MTA—My Talk Address

The primary listen and talk addresses are established by the TS-4084/G GPIB address (internally set).

LLO—Local Lockout

In response to LLO, the TS-4084/G 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 TS-4084/G 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.

Remote-Local Operation

The preceding discussion described the state transitions caused by GTL and REN. The LEVEL, THD+N, SINAD of FILTERS pushbuttons cause a transition from REMS to LOCS by asserting a message called retum-to-local (rtl). This transition may occur during message execution. In contrast to GTL and REN transitions, a transition initiated by rtl 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 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 pushbutton. When in LOCS, only bus commands that do not change instrument settings are executed (query-output commands). All other bus commands (setting and operationl) 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 rtl 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.

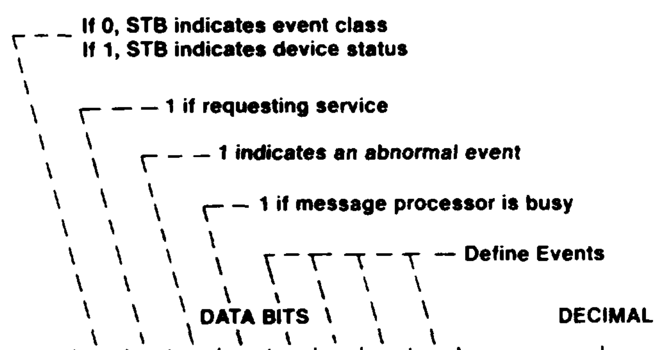
Both the input range and distortion range are forced to auto-range except when the “FPset” command is used (see FPset).

Remote With Lockout State (RWLS)

Instrument operation is identical to REMS operation excxept the rtl 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. 6-3. When data bit 8 is set, the STB conveys Device Status information indicated by bits 1 through 4.



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

CE0JR015

Fig. 6-3. 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 to instruments in a system (e.g., Power on, User Request, etc.).

INTERNAL WARNINGS
The instrument has detected a problem. The instrument remains operational but the problem Should be corrected.

DEVICE STATUS
Device dependent events.

The instrument can provide additional information about many of the events, particularly the errors reported in the Event Query. 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 6-1.

Table 6-1
ERROR QUERY AND STATUS INFORMATION

Event	Bus response to ERR?	Response to serial poll[a]
Abnormal Conditions		
Command Errors		
Command header error	101	97 or 113
Header delimiter error	102	97 or 113
Command argument error	103	97 or 113
Argument delimiter error	104	97 or 113
Missing argument	106	97 or 113
Invalid message unit delimiter	107	97 or 113
Execution Errors		
Command not executable in local mode	201	98 or 114
Returned to local, new pending settings lost	202	98 or 114
I/O buffers full, output dumped	203	98 or 114
Argument out of range	205	98 or 114
Group execute trigger ignored	206	98 or 114
Internal Errors		
Interrupt fault	301	99 or 115
System error	302	99 or115
Math pack error	303	99 or 115
Normal Conditions		
System Events		
Power on	401	65 or 81
Operation complete	402	66 or 82
Internal Warning		
Display overrange	601	68 or 84
Device Dependent Events		
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	

[a] **If the message processor is busy, the instrument returns the higher decimal number.**

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 (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.

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 returns 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 RQS OFF the controller may perform a Serial Poll, but the Status Byte only contains Device Dependent Status information. With RQS 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 TS-4084/G 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 Table 6-2. The SRQ line GPIB is asserted. If an internal error is found, an error code is displayed in the front-panel readout. See Table 6-2 for error codes.

The instrument goes to the following setting at power on and when the INit command is executed.

Table 6-2
POWER ON SETTINGS

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

APPENDIX A

REFERENCES

A-1. SCOPE.

This appendix lists all forms, technical bulletins, technical manuals, and miscellaneous publications referenced in this manual.

A-2. FORMS.

Recommended Changes to Publications and Blank Form	DA Form 2028
Recommended Changes to Equipment Technical Manuals	DA Form 2028-2
Report of Discrepancy.	Form SF 364
Quality Deficiency Report	Form SF 368

A-3. TECHNICAL MANUALS.

The Army Maintenance Management System (TAM MS)	DA Pam 738-750
Administrative Storage Procedures..	TM 740-90-1
Procedures for Destruction of Electronics Materiel to Prevent Enemy Use (Electronics Command)	TM 750-244-2
Organizational, Direct Support, and General Support Repair Parts and Special Tools List for Distortion Analyzer TS-4084/G	TM 11-6625-3152-24P

A-4. MISCELLANEOUS.

Common Table of Allowances	CTA 50-970
Consolidated Index of Army Publications and Blank Forms	DA Pam 310-1
First Aid for Soldiers	FM 21-11
Abbreviations for Use on Drawings, Specifications, Standards and in Technical Documents	MIL-STD-12
Preservation, Packaging, Packing and Marking Materials, Supplies and Equipment Used By the Army.	SB 38-100

APPENDIX C
ADDITIONAL AUTHORIZATION LIST

Section 1
INTRODUCTION

C-1. SCOPE

This appendix lists additional items you are authorized for the support of the TS-4084/G.

C-2. GENERAL

This list identifies items that do not have to accompany the TS-4084/G and that do not have to be turned in with It. These Hems are all authorized to you by CTA, MTOE, TDA, or JTA.

C-3. EXPLANATION OF LISTING

National stock numbers, descriptions, and quantities are provided to help you identify and request the additional items You require to support this equipment. The items are listed In alphabetical sequence by item name under the ‘type document (i.e., CTA, MTOE, TDA, or JTA) which authorlzes the item(s) to you.

Section 2
ADDITIONAL AUTHORIZATION LIST

(1) NATIONAL STOCK NUMBER	(2) DESCRIPTION FSCM & PART NUMBER	USABLE ON CODE	(3) U/M	(4) QTY AUTH
5920-00-050-4953	Fuse Cartridge, 3AG, 1.5A, 250V, Fast Blow 71400, AGC-CM-1½		ea.	1
5920-00-280-8342	Fuse Cartridge, 3AG, 1A, 250V, Medium Blow 71400, AGC-CM-1		ea.	1
5920-01-154-0068	Fuse Cartridge, 3AG, 0.3A, 250V, Medium Blow 71400, AGC-CM-0.3		ea.	1
5920-00-329-8475	Fuse Cartridge, 3AG, 0.6A, 250V, Medium Blow 71400, AGC-CM-0.6		ea.	1

APPENDIX D
MAINTENANCE ALLOCATION CHART (MAC)

INTRODUCTION

The Army Maintenance System MAC

This introduction provides a general explanation of all maintenance and repair function authorized at the two maintenance levels under the Two-Level Maintenance System concept.

This MAC (immediately following the introduction) designates overall authority and responsibility for the performance of maintenance functions on the identified end item or component. The application of the maintenance functions to the end item or component levels, which are shown on the MAC in column (4) as:

> Field – includes two columns, Unit maintenance and Direct Support maintenance. The Unit maintenance column is divided again into two more subcolumns, C for Operator or Crew and O for Unit maintenance.
> Sustainment – includes two subcolumns, general support (H) and depot (D).

The tools and test equipment requirements (immediately following the MAC) list the tools and test equipment (both special tools and common tool sets) required for each maintenance function as referenced from the MAC.

The remarks (immediately following the tools and test equipment requirements) contain supplemental instructions and explanatory notes for a particular maintenance function.

Maintenance Functions

Maintenance functions are limited to and defined as follows:

1. Inspect. To determine the serviceability of an item by comparing its physical, mechanical, and/or electrical characteristics with established standards through examination (e.g. by sight, sound, or feel). This includes scheduled inspection and gagings and evaluation of cannon tubes.

2. Test. To verify serviceability by measuring the mechanical, pneumatic, hydraulic, or electrical characteristics of an item and comparing those characteristics with prescribed standards on a scheduled basis, i.e., load testing of lift devices and hydrostatic testing of pressure hoses.

3. Service. Operations required periodically to keep an item in proper operating condition; e.g., to clean (includes decontaminate, when required), to preserve, to drain, to paint, or to replenish fuel, lubricants, chemical fluids, or gases. This includes scheduled exercising and purging of recoil mechanisms. The following are examples of service functions:

   a. Unpack. To remove from packing box for service or when required for the performance of maintenance operations.
   b. Repack. To return item to packing box after service and other maintenance operations.
   c. Clean. To rid the item of contamination.
   d. Touch up. To spot paint scratched or blistered surfaces.
   e. Mark. To restore obliterated identification.

4. Adjust. To maintain or regulate, within prescribed limits, by bringing into proper position, or by setting the operating characteristics to specified parameters.

APPENDIX D
MAINTENANCE ALLOCATION CHART (MAC)

5. Align. To adjust specified variable elements of an item to bring about optimum or desired performance.

6. Calibrate. To determine and cause corrections to be made or to be adjusted on instruments of test, measuring, and diagnostic equipment used in precision measurement. Consists of comparisons of two instruments, one of which is a certified standard of known accuracy, to detect and adjust any discrepancy in the accuracy of the instrument being compared.

7. Remove/install. To remove and install the same item when required to perform service or other maintenance functions. Install may be the act of emplacing, seating, or fixing into position a spare, repair part, or module (component or assembly) in a manner to allow the proper functioning of an equipment or system.

8. Paint. To prepare and spray color coats of paint so that the ammunition can be identified and protected. The color indicating primary use is applied, preferably, to the entire exterior surface as the background color of the item. Other markings are to be repainted as original so as to retain proper ammunition identification.

9. Replace. To remove an unserviceable item and install a serviceable counterpart in its place "Repair" is authorized by the MAC and assigned maintenance level is shown as the third position code of the Source, Maintenance and Recoverability (SMR) code.

10. Repair. The application of maintenance services, including fault location/troubleshooting, removal/installation, disassembly/assembly procedures and maintenance actions to identify troubles and restore serviceability to an item by correcting specific damage, fault, malfunction, or failure in a part, subassembly, module (component or assembly), end item or system.

NOTE

The following definitions are applicable to the "repair" maintenance function:

Services. Inspect, test, service adjust, align, calibrate, and/or replace.
Fault location/troubleshooting. The process of investigating and detecting the case of equipment malfunctioning; the act of isolating a fault within a system or Unit Under Test (UUT).
Disassembly/assembly. The step-by-step breakdown (taking apart) of aspare/functionalgroup coded item to the level of its least component, that is assigned an SMR code for the level of maintenance under consideration (i.e., identified as maintenance significant).
Actions. Welding, grinding, riveting, straightening, facing, machining, and/or resurfacing.

11. Overhaul. That maintenance effort (service/action) prescribed to restore an item to a completely serviceable/operational condition as required by maintenance standards in appropriate technical publications. Overhaul is normally the highest degree of maintenance performed by the Army. Overhaul does not normally return an item to like new condition.

12. Rebuild. Consists of those services/actions necessary for the restoration of unserviceable equipment to a like new condition in accordance with original manufacturing standards. Rebuild is the highest degree of material maintenance applied to Army equipment. The rebuild operation includes the act of returning to zero those age measurements (e.g., hours/miles) considered in classifying army equipment/components.

APPENDIX D
MAINTENANCE ALLOCATION CHART (MAC)

Explanation of Columns in the MAC

Column (1) Group Number, Column (1) lists FGC numbers, the purpose of which is to identify maintenance significant components, assemblies, subassemblies, and modules with the Next Higher Assembly (NHA).

Column (2) Component/Assembly. Column (2) contains the item names of components, assemblies, subassemblies, and modules for which maintenance is authorized.

Column (3) Maintenance Function. Column (3) lists the functions to be performed on the item listed in column (2). (For a detailed explanation of these functions, refer to "Maintenance Functions" outlined above.)

Column (4) Maintenance Level. Column (4) specifies each level of maintenance authorized to perform each function listed in column (3), by indicating work time required (expressed as manhours in whole hours or decimals) in the appropriate subcolumn. The work time figure represents the active time required to perform that maintenance function at the indicated level of maintenance. If the number or complexity of the tasks within the listed maintenance function varies at different maintenance levels, appropriate work time figures are to be shown for each level. The work time figure represents the average time required to restore an item (assembly, subassembly, component, module, end item or system) to a serviceable condition under typical field operating conditions. This time includes preparation time (including any necessary disassembly/assembly time), troubleshooting/fault location time, and quality assurance time in addition to the time required to perform the specific tasks identified for the maintenance functions authorized in the MAC. The symbol designations for the various maintenance levels are as follows:

Field:
- C Operator or Crew maintenance
- O Unit maintenance
- F Direct Support maintenance

Sustainment:
- L Specialized Repair Activity
- H General Support maintenance
- D Depot maintenance

NOTE

The "L" maintenance level is not included in column (4) of the MAC. Functions to this level of maintenance are identified by work time figure in the "H" column of column (4), and an associated reference code is used in the REMARKS column (6). This code is keyed to the remarks and the SRA complete repair application is explained there.

Column (5) Tools and Equipment Reference Code. Column (5) specifies, by code, those common tool sets (not individual tools), common Test, Measurement and Diagnostic Equipment (TMDE), and special tools, special TMDE and special support equipment required to perform the designated function. Codes are keyed to the entries in the tools and test equipment table.

Column (6) Remarks Code. When applicable, this column contains a letter code, in alphabetical order, which is keyed to the remarks table entries.

APPENDIX D
MAINTENANCE ALLOCATION CHART (MAC)

MAINTENANCE ALLOCATION CHART FOR DISTORTION ANALYZER

Table 1. MAC for Distortion Analyzer TS-4084/G

(1) GROUP NUMBER	(2) COMPONENT/ASSEMBLY	(3) MAINTENANCE FUNCTION	(4) MAINTENANCE LEVEL FIELD UNIT C		FIELD DS F	SUSTAINMENT GS H	SUSTAINMENT DEPOT D	(5) TOOLS AND EQUIPMENT REFERENCE CODE	(6) REMARKS
			C	O	F	H	D		
00	DISTORTION ANALYZER TS-4084/G	INSPECT		0.1					A
		TEST		0.1					B
		TEST			0.2				
		SERVICE	0.1						
		CALIBRATE			1.5				C
		ADJUST			1.0			2 THRU 27	
		REPAIR		0.1				1	D
		REPAIR			2.0			2 THRU 27	E, F. G
01	MAIN BOARD	INSPECT			0.1				A
		REPAIR			0.2			1, 2 5	G

APPENDIX D
MAINTENANCE ALLOCATION CHART (MAC)

TOOL AND TEST EQUIPMENT REQUIREMENTS FOR DISTORTION ANALYZER

Table 2. Tools and Test Equipment for Distortion Analyzer TS-4084/G

(1) TOOLS OR TEST EQUIPMENT REF CODE	(2) MAINTENANCE LEVEL	(3) NOMENCLATURE	(4) NATIONAL STOCK NUMBER	(5) TOOL NUMBER
1	O	TOOL KIT, ELECTRONIC	5180-00-064-5178	TK-101/G
2	F	TOOL KIT, ELECTRONIC	4931-01-073-3845	JTK-17A
3	F	AC VOLTAGE CALIBRATOR	6625-01-063-6325	5200A (89536)
4	F	COUNTER, FREQUENCY	6625-01-114-4890	DC 503A, OPT 1 (80009)
5	F	MULTIMETER, DIGITAL	6625-01-075-8583	MIS-30526/4 (80009)
6	F	OSCILLATOR, SINE WAVE, LOW DISTORTION	6625-01-150-7879	SG 505
7	F	GENERATOR, FUNCTION	6695-01-074-7956	MIS-30526/5 (80009)
8	F	POWER MODULE, MAIN FRAME	6625-01-048-8920	MIS-30526/1TY1 (80009)
9	F	OSCILLOSCOPE	6625-01-034-3269	MIS-28706/1TY2 (80009)
10	F	AMPLIFIER, DUAL TRACE, PLUG-IN	4931-01-008-1480	MIS-28706/3 (80009)
11	F	TIME BASE, PLUG-IN	4931-01-008-1479	MIS-28706/4 (80009)
12	F	CONTROLLER/DISPLAY	6625-01-206-5809	1722A/AP (89536)
13	F	KEYBOARD	6695-01-186-7902	Y1700 (89536)
14	F	GPIB CABLE		81190-010 (BERG ELECTR)
15	F	ADAPTER, BNC FEMALE TO DUAL BANANA	6625-00-900-4276	7907471 (18876)
16	F	CABLE 42' COAXIAL (50Ω) BNC CONNECTORS	4931-00-842-9273	10519140 (18876)
17	F	CONNECTOR"T" BNC	5935-00-259-0205	103-0045-00 (80009)
18	F	AC VOLTAGE STANDARD	4931-01-012-2884	745A (28480)
19	F	AMPLIFIER, HV	6625-00-152-2316	746A (28480)
20	F	PATCH CORD, BANANA TO BANANA	4931-00-846-0010	7907470 (18876)
21	F	SHORTING BAR	5895-00-981-4677	134-0012-00 (80009)
22	F	1 M OHM/20pf INPUT NORMALIZER	5895-00-482-4576	067-0538-00 (80009)
23	F	50Ω 10X ATTENUATOR	5985-00-572-7428	011-0059-02 (80009)
24	F	50Ω FEEDTHROUGH TERMINATION	5985-00-087-4954	990C696H01 (18323)
25	F	SERVICE CABLE KIT		067-1156-00 (80009)
26	F	ANALYZER EXTENDER CABLE	5998-01-300-3671	067-0645-02 (80009)
27	F	GPIB EXTENDER CABLE		067-0996-00 (80009)

APPENDIX D
MAINTENANCE ALLOCATION CHART (MAC)

REMARKS FOR VOLTMETER ME-545/G

Table 3. Remarks for Distortion Analyzer TS-4084/G

REMARKS CODE	REMARKS
A	VISUAL INSPECTION.
B	OPERATIONAL TEST.
C	CALIBRATE USING TECHNICAL BULLETIN TB 43-180.
D	KNOBS AND MAIN POWER FUSE ARE REPLACED AT THE ORGANIZATIONAL LEVEL.
E	REPAIR IS IMPLEMENTED BY REPLACEMENT OF FAN, TRANSFORMER, POWER TRANSISTORS, POWER SWITCH ASSEMBLY, BOARDS A10, A11, A12, A14, A15, A16, A20, A30, AND A35.
F	REPAIR IS IMPLEMENTED BY REPLACEMENT OF FRONT PANEL CONNECTORS.
G	REPAIR IS IMPLEMENTED BY REPLACEMENT OF INTERNAL FUSES ON A15 BOARD.

APPENDIX E

Section 1

INTRODUCTION

E-1. Scope

This appendix lists expendable supplies and materials you will need to operate and maintain the TS-4084/G. These items are authorized to you by CTA 50-70, Expendable Items (Except Medical, Class V, Repair parts, and Heraldic Items).

E-2. Explanation of Columns

a. Column (1) — Item Number. This number is assigned to the entry in the listing and is referenced in the narrative instructions to identify the material (e.g., "Use cleaning compound, item 1, App. E").

b. Column (2) — Level. This column identifies the lowest level of maintenance that requires the listed.

C — Operator/Crew
O — Organizational Maintenance
F — Direct Support Maintenance
H — General Support Maintenance

c. Column (3) — National Stock Number. This is the National stock number assigned the item; use it to request or requisition the item.

d. Column (4) — Description. Indicates the Federal item name and, if required, a description to identify the item. The last line for each item indicates the Federal Supply Code for Manufacturer (FSCM) in parentheses followed by the part number.

e. Column (5) — Unit of Measure (U/M). Indicates the measure used in performing the actual maintenance function. This measure is expressed by a two-character alphabetical abbreviation (e.g., ea, in, pr). If the unit of measure differs from the unit of issue, requisition the lowest unit of issue that will satisfy your requirements.

Section 2

EXPENDABLE SUPPLIES AND MATERIALS LIST

(1) ITEM NUMBER	(2) LEVEL	(3) NATIONAL STOCK NUMBER	(4) DESCRIPTION	(5) U/M
1	O	6810-00-753-4993	ALCOHOL, ISOPROPYL, 8 OZ CAN MIL-A-10428, GRADE A (81349)	OZ
2	C	8305-00-267-3015	CLOTH, CHEESECLOTH, COTTON, LINTLESS, CCC-C-440, TYPE II, CLASS 2 (81348)	YD
3	C		DETERGENT, MILD LIQUID	OZ

SUBJECT INDEX

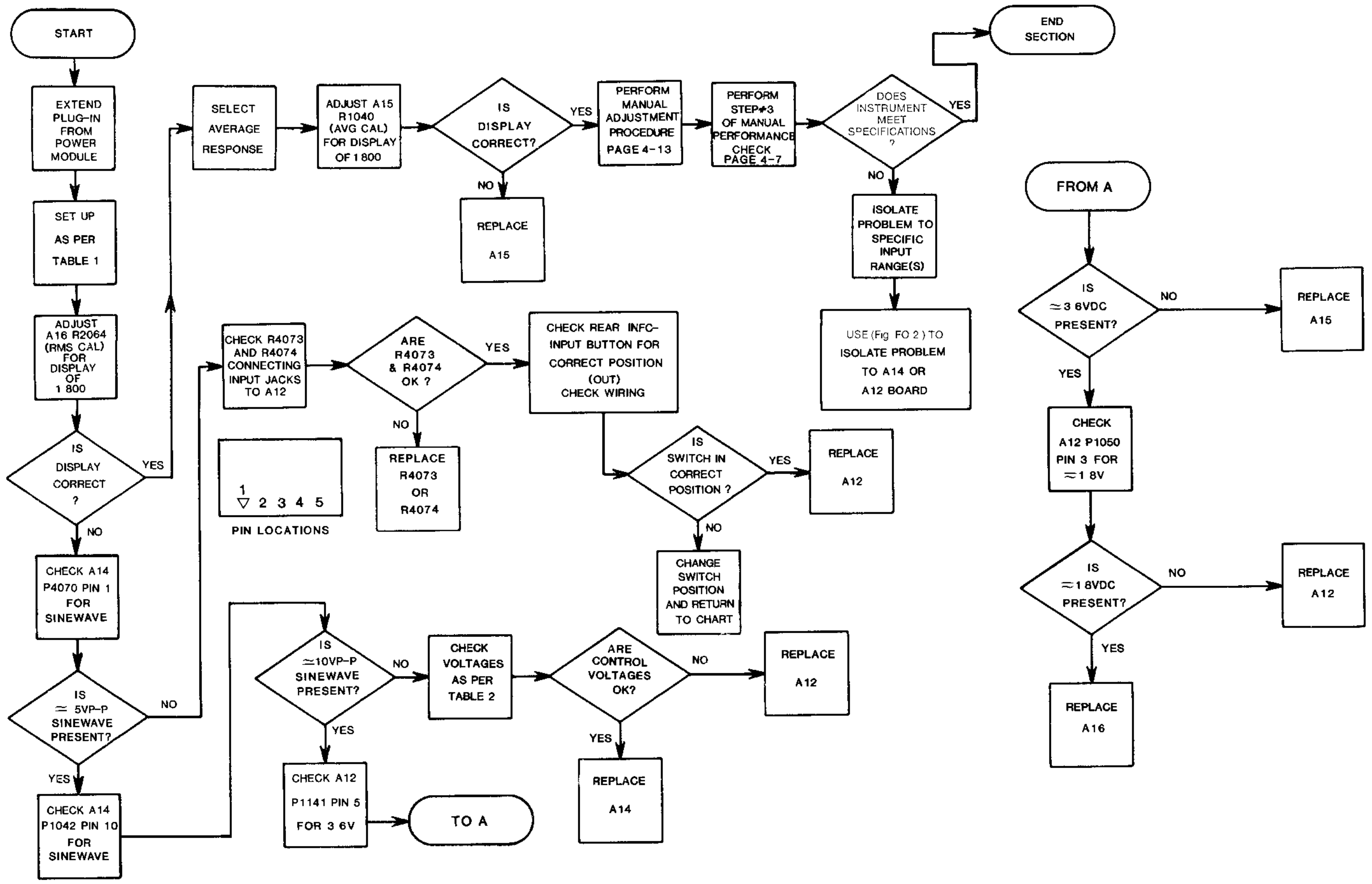
SUBJECT (CONT'D)	PARA., FIGURE, TABLE NUMBER	PAGE

P

Q

R

S



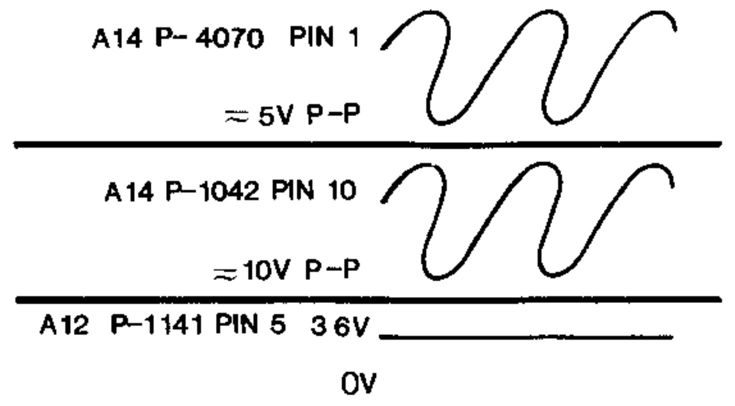


TABLE 1

1 APPLY 1 800V RMS AT 1KHz TO TS4084 INPUT FROM AC VOLTAGE CALIBRATOR
2 INPUT RANGE -2V
3 FUNCTION - VOLTS/LEVEL (IN)
4 RESPONSE - RMS (IN)
5 ALL OTHER BUTTONS OUT

TABLE 2		FUNCTION-VOLTS-LEVEL INPUT RANGE-2V
CONNECTOR	PIN NUMBER	EXPECTED VOLTAGE
A14- P1060	2	≈ 0V
A14- P1060	3	≈ 0V
A14- P1060	4	≈ 0V
A14- P1060	5	≈ 0V
A14- P1060	6	+12V
A14- P1060	7	≈0V
A14- P1060	8	≈ 0V
A14- P1030	6	≈ 0V
A14- P1030	7	≈ 0V
A14- P1030	8	+12V
A14- P1070	1	≈ 0V
A14- P1070	2	≈ 0V
A14- P1070	3	+ 5V
A14- P1070	4	-15V
A14- P1070	5	+ 5V

Figure FO-1. Volts-Level Function Troubleshooting

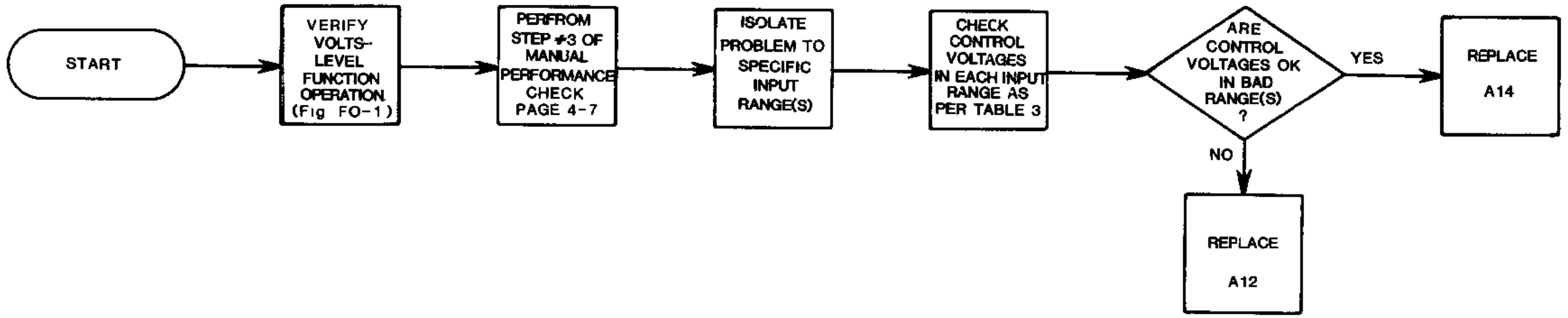
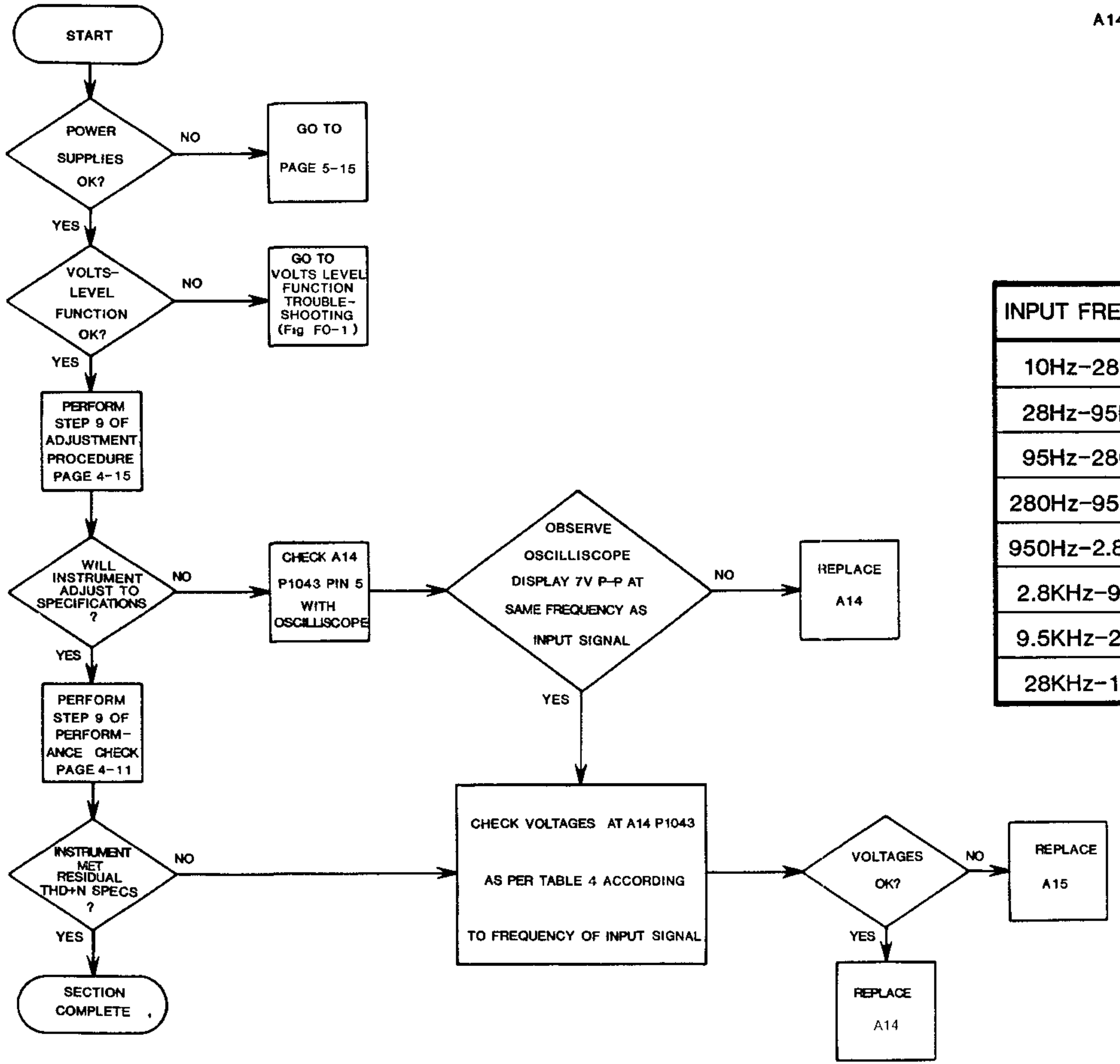
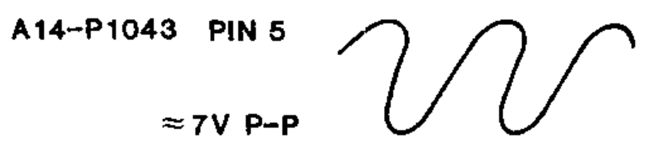


TABLE 3

TEST POINTS	INPUT RANGE SETTING							L=0V H=+12V		
CONNECTOR/PIN	200uV	2mV	20mV	200mV	600mV	2V	6V	20V	60V	200V
A14-P1060 PIN 2	L	L	L	L	L	L	L	L	L	H
A14-P1060 PIN 3	L	L	L	L	L	L	L	L	H	L
A14-P1060 PIN 4	L	L	L	L	L	L	L	H	L	L
A14-P1060 PIN 5	L	L	L	L	L	L	H	L	L	L
A14-P1060 PIN 6	L	L	L	L	L	H	L	L	L	L
A14-P1060 PIN 7	L	L	L	L	H	L	L	L	L	L
A14-P1060 PIN 8	H	H	H	H	L	L	L	L	L	L
A14-P1030 PIN 6	H	L	H	L	L	L	L	L	L	L
A14-P1030 PIN 7	H	H	L	L	L	L	L	L	L	L
A14-P1030 PIN 8	H	H	H	H	L	H	L	H	L	H

Figure FO-2. Volts-Level Function Range Troubleshooting





	A14-P1043		L ≈ 0V H ≈ +4V	
INPUT FREQUENCY	PIN 1	PIN 2	PIN 3	PIN 4
10Hz-28Hz	H	L	H	H
28Hz-95Hz	H	H	H	H
95Hz-280Hz	L	L	H	H
280Hz-950Hz	L	H	H	H
950Hz-2.8KHz	L	L	L	H
2.8KHz-9.5KHz	L	H	L	H
9.5KHz-28KHz	L	L	L	L
28KHz-100KHz	L	H	L	L

Figure FO-3 THD + N Function Troubleshooting

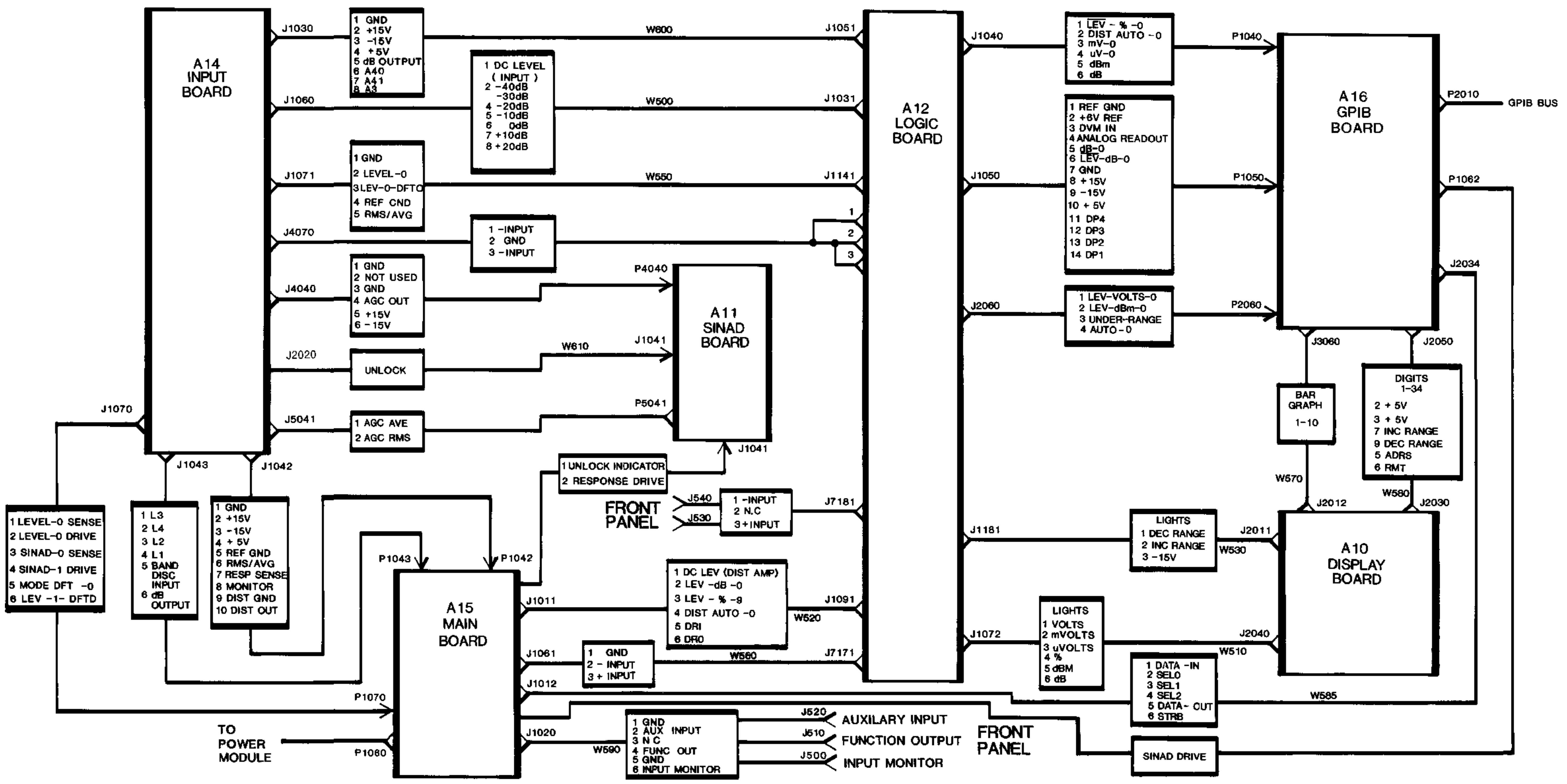


Figure FO-4. Interconnect Diagram

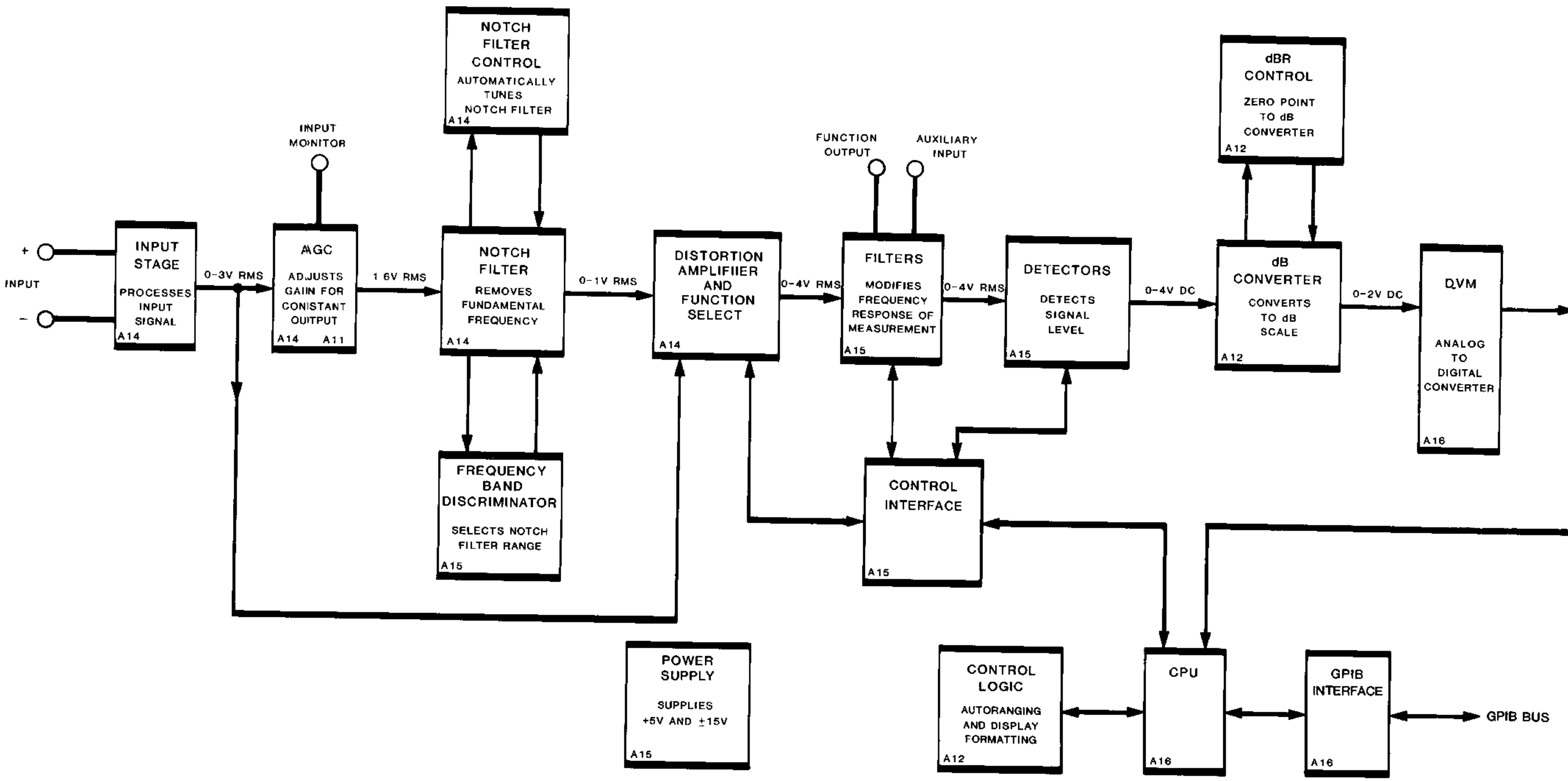


Figure FO-5. Block Diagram

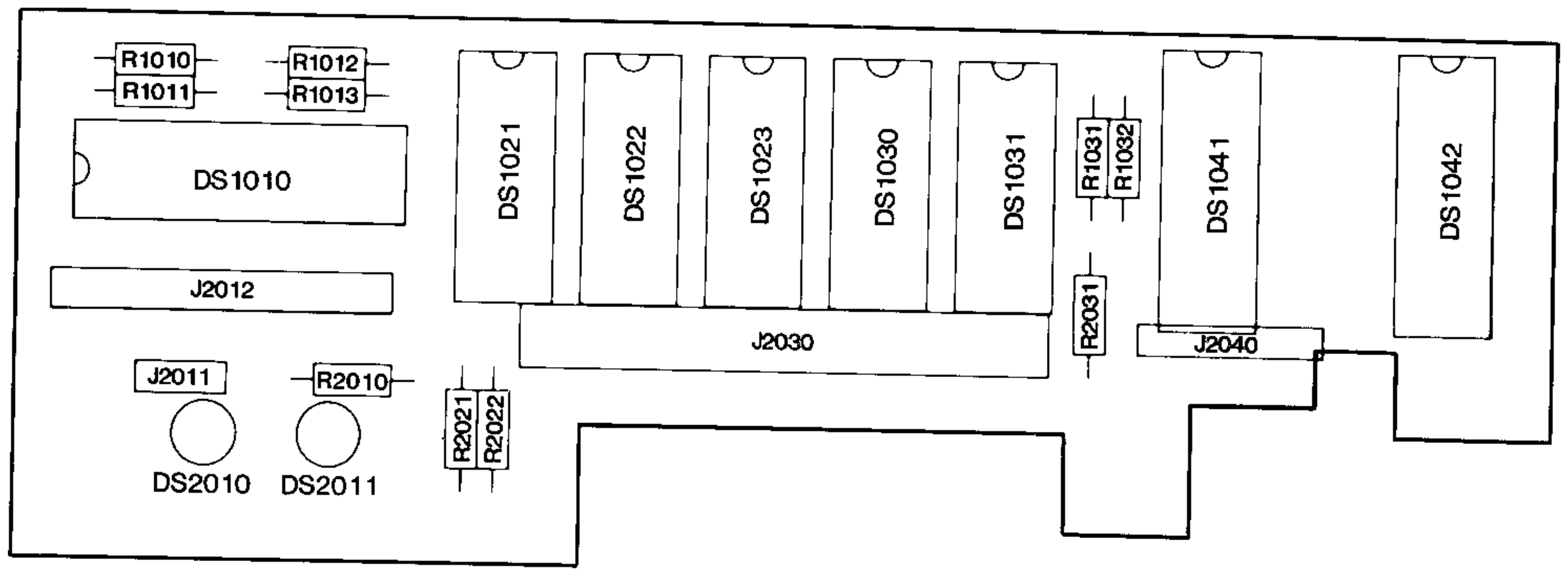


Figure FO-6. (A10) Display Board Layout

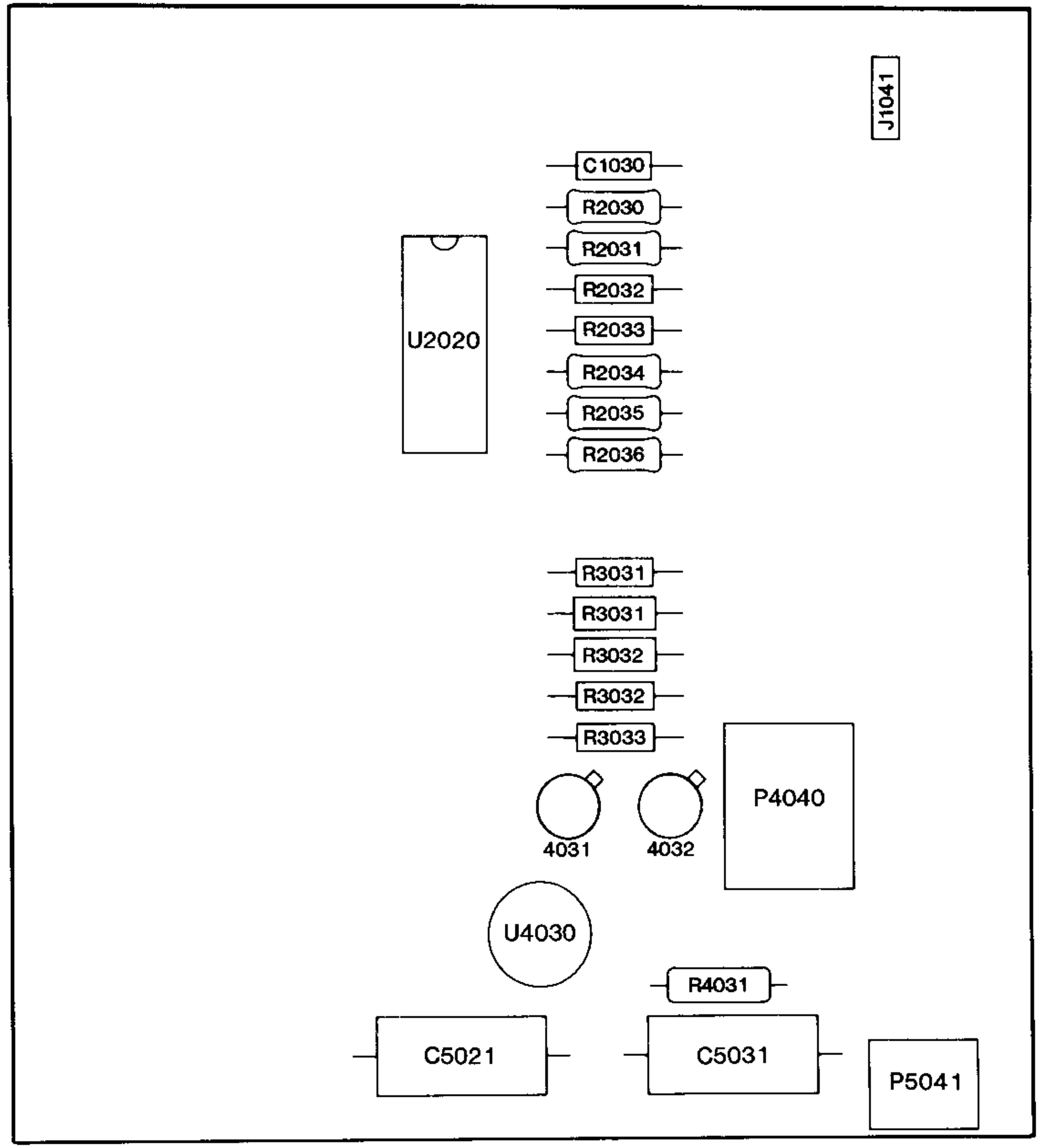
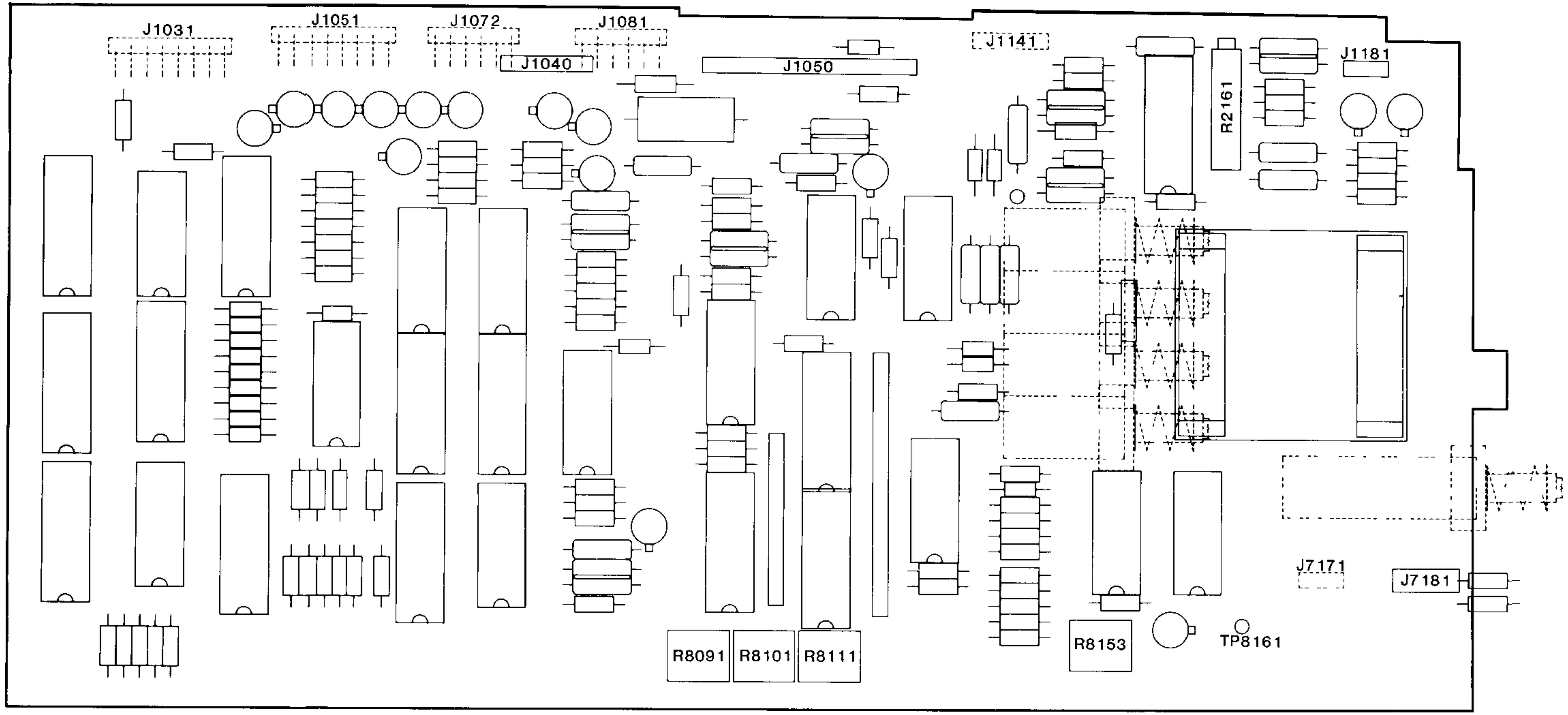
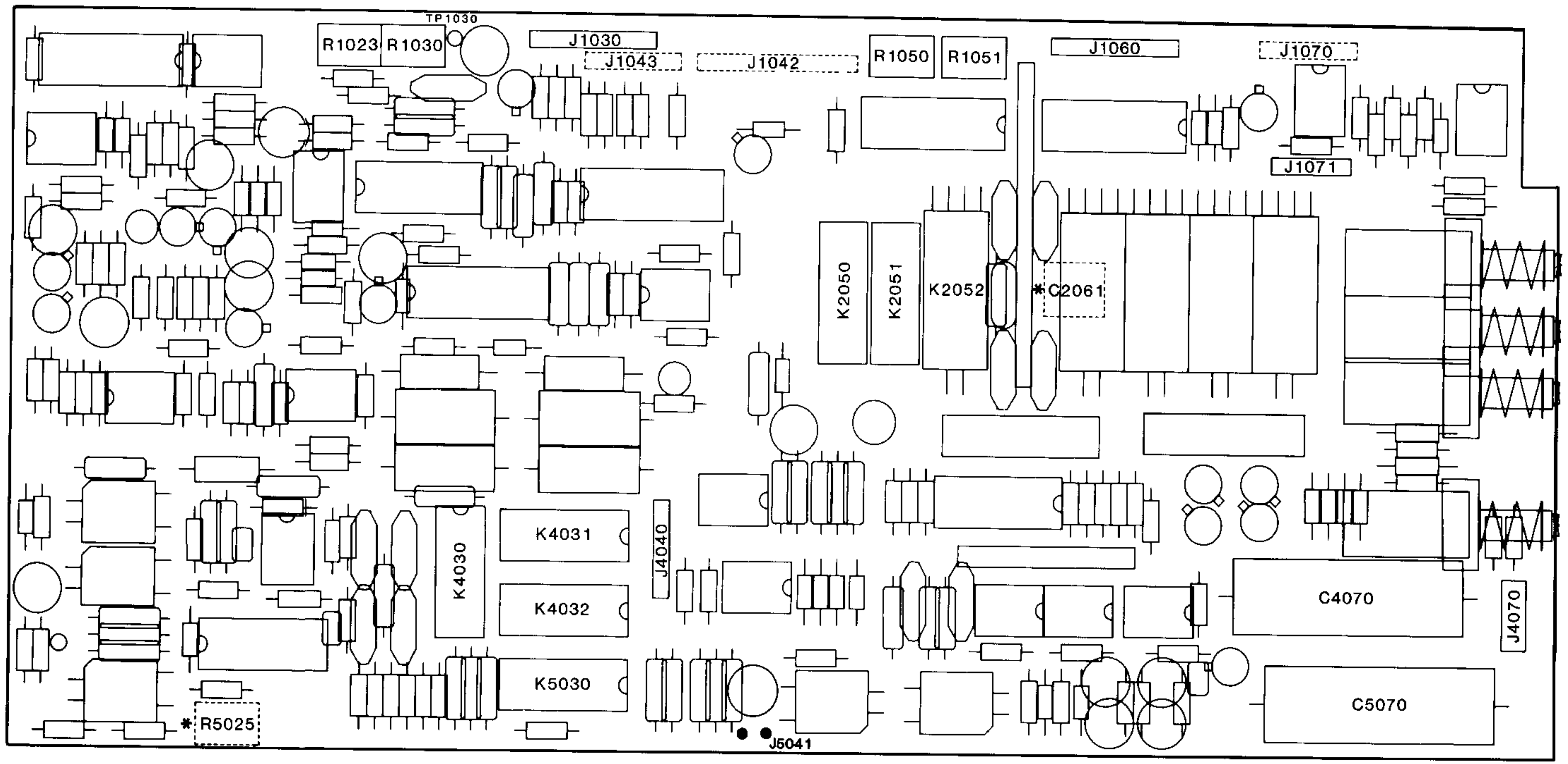


Figure FO-7. (A11) Sinad Board Layout



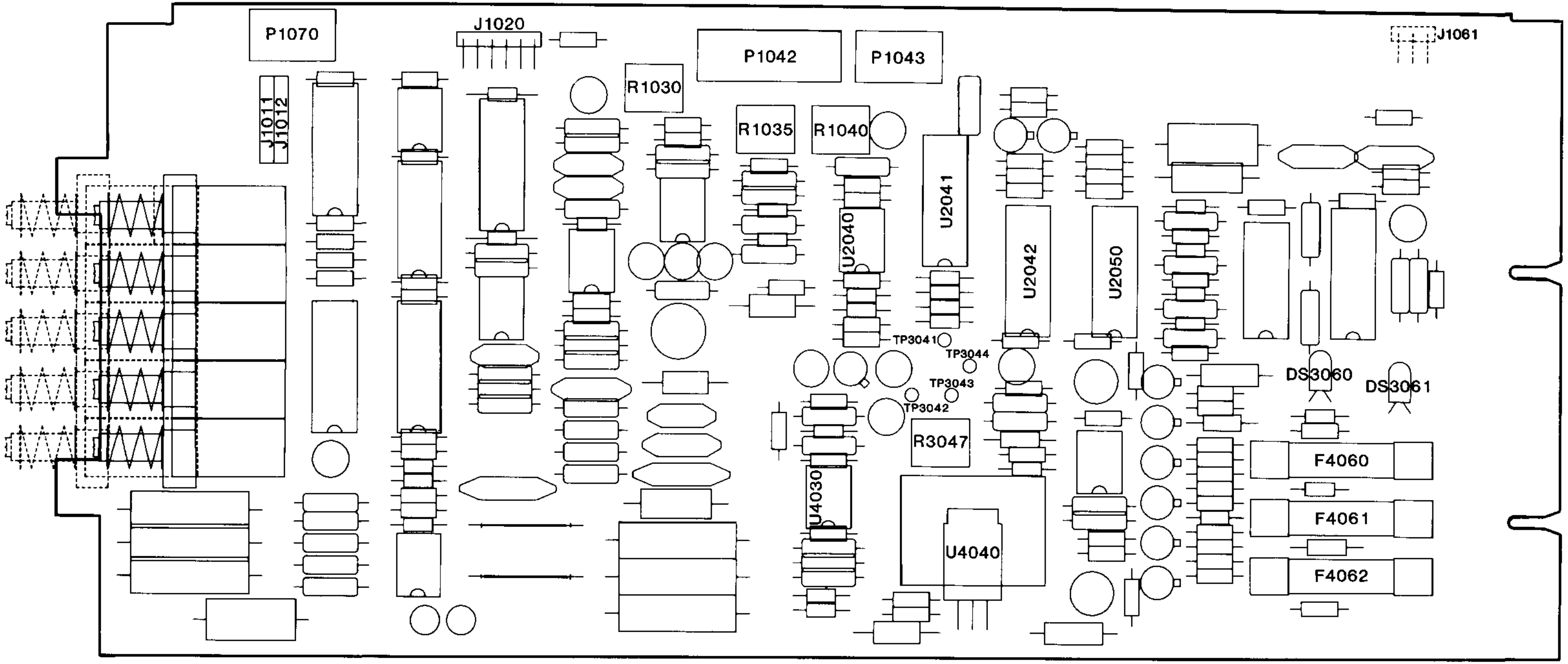
NOTE DOTTED LINES INDICATES COMPONENT ON REAR BOARD

Figure FO-8. (A12) Logic Board Layout



NOTE DOTTED LINES INDICATES COMPONENT ON REAR OF BOARD

Figure FO-9. (A14) Input/Notch Filter Board Layout



NOTE DOTTED LINES INDICATES COMPONENT ON REAR BOARD

Figure FO-10. (A15) Main Board Layout

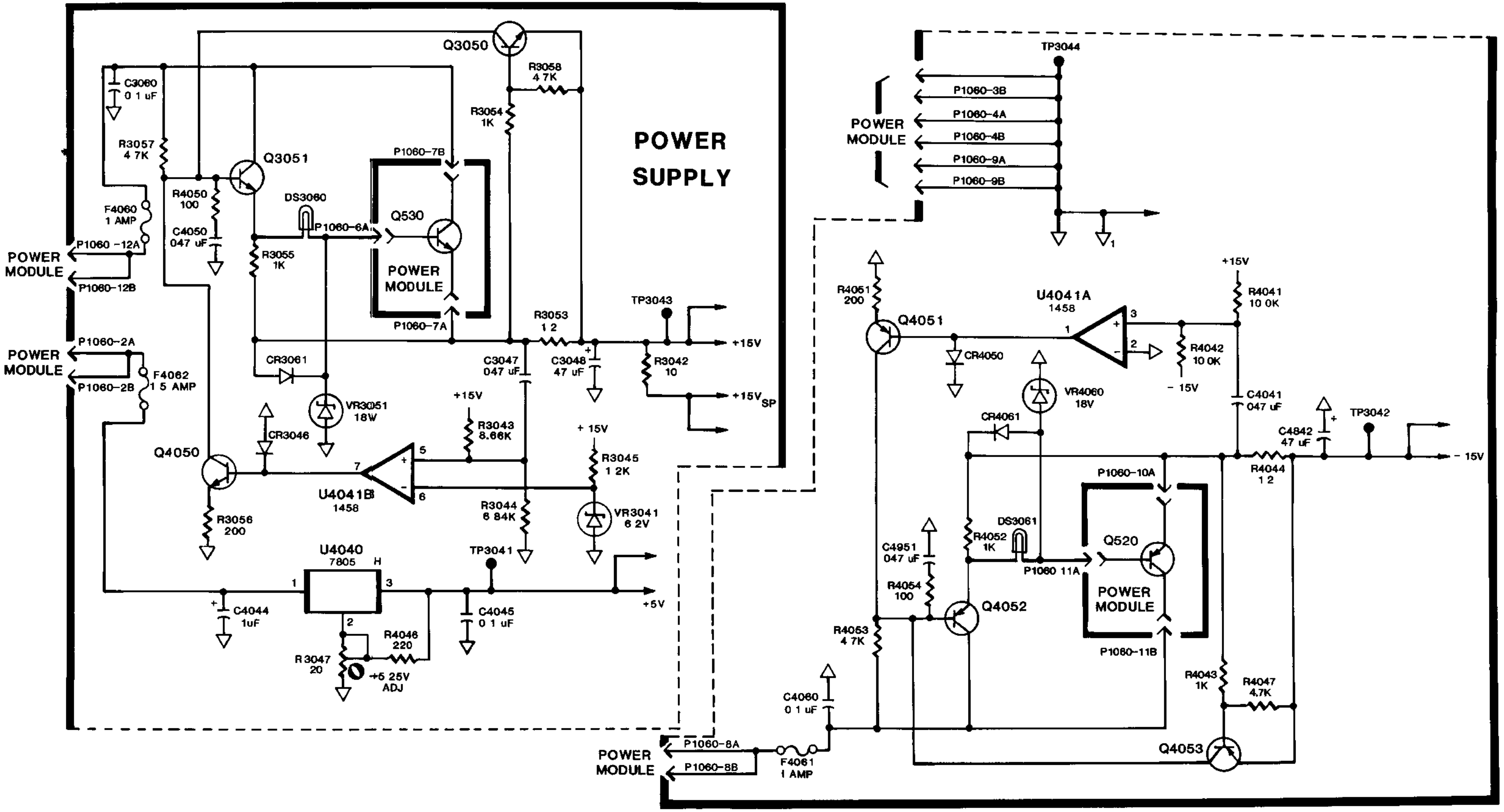


Figure FO-11. (A15) Power Supply Schematic

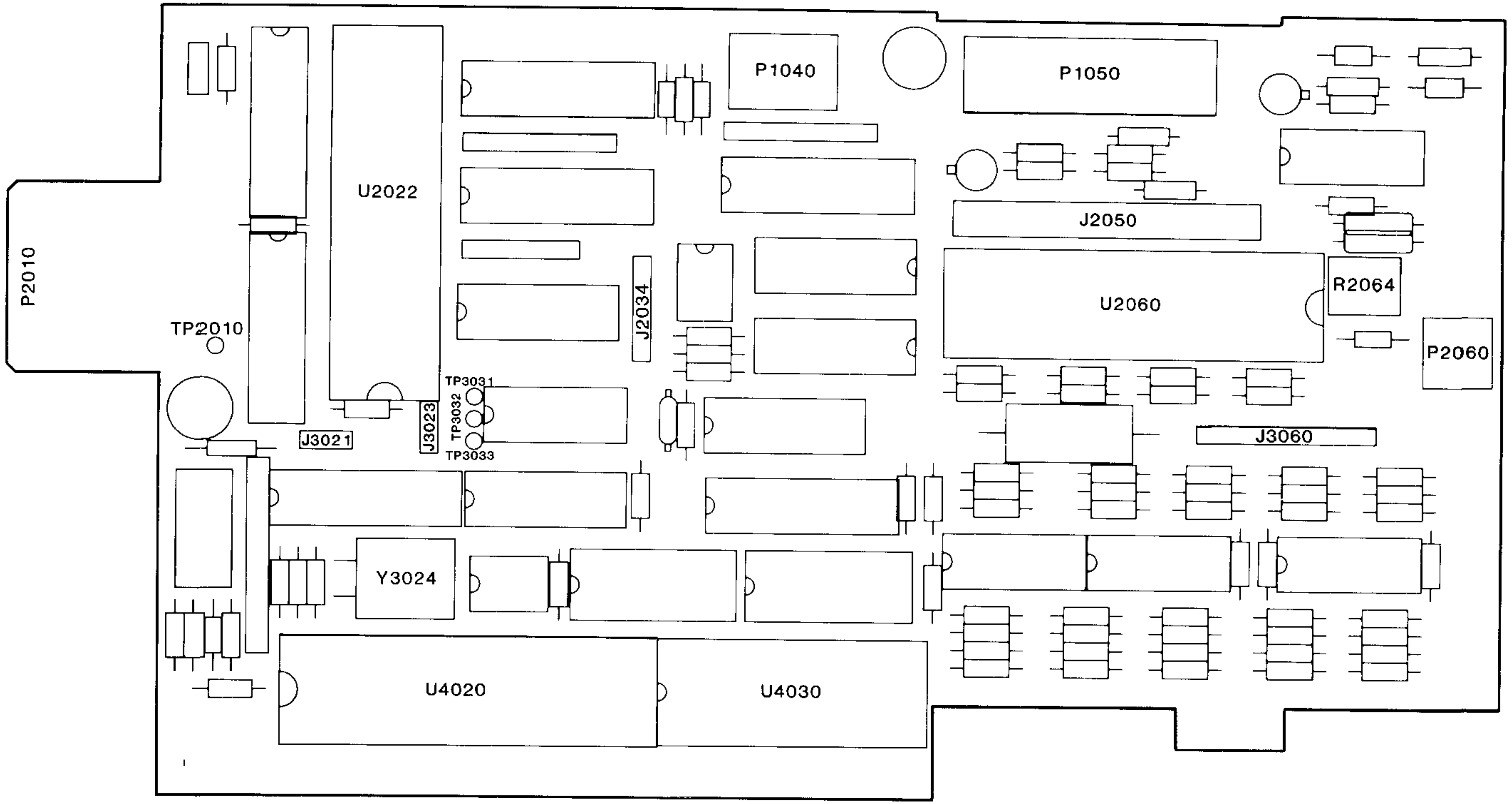


Figure FO-12. (A16) GPIB Board Layout

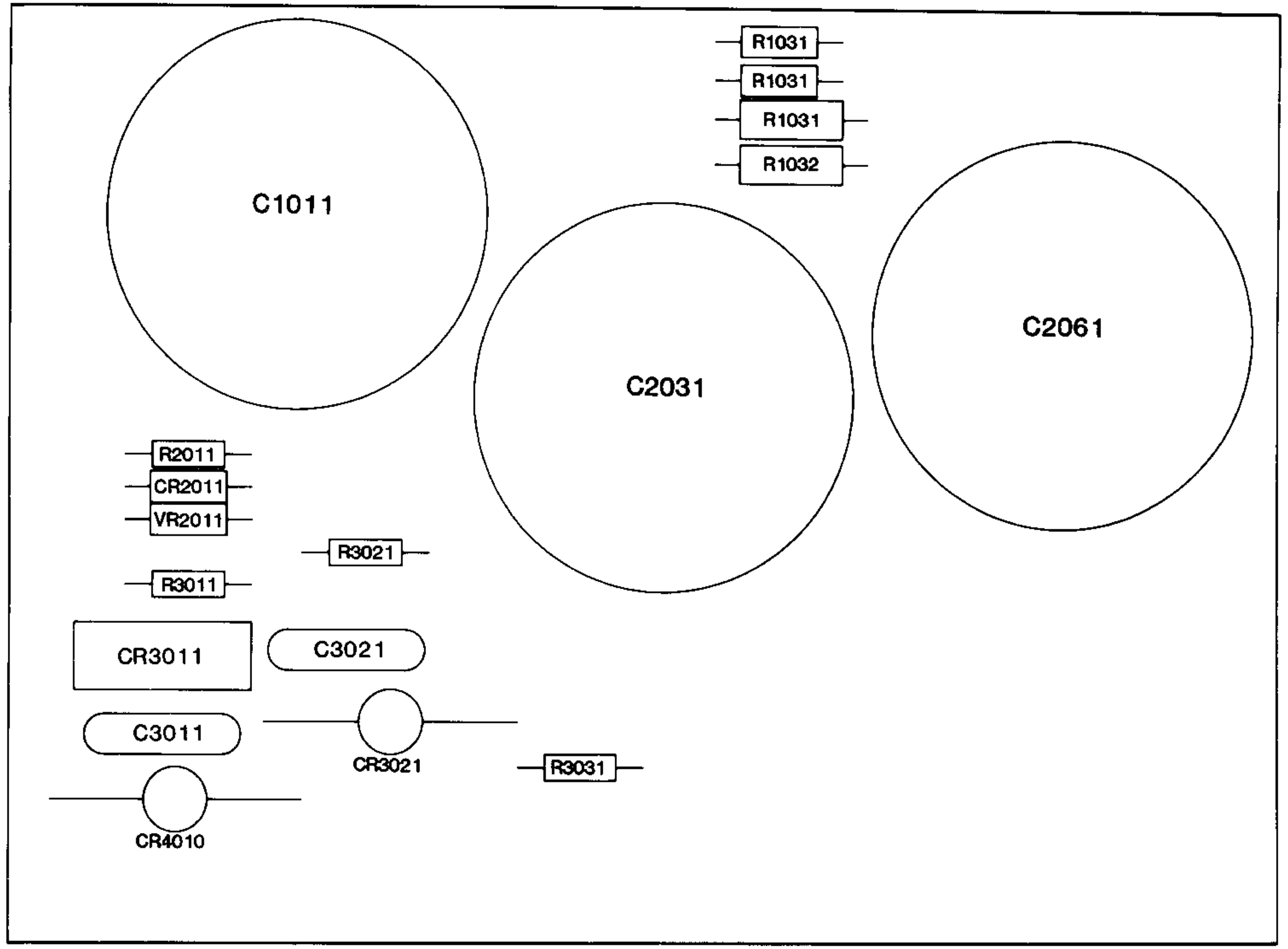


Figure FO-13. (A20) Main Power Supply Board Layout

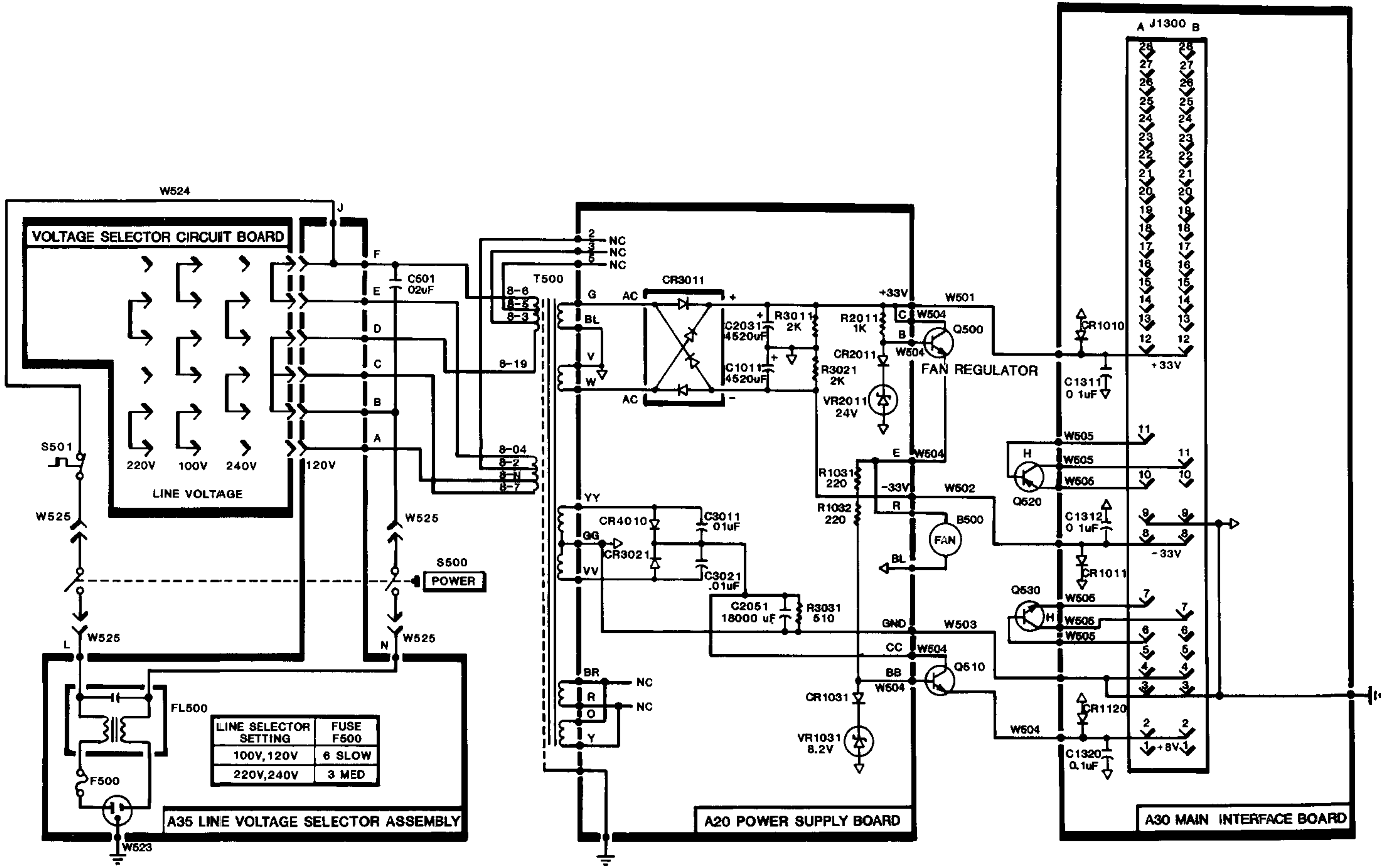


Figure FO-14. Main Power Supply Schematic

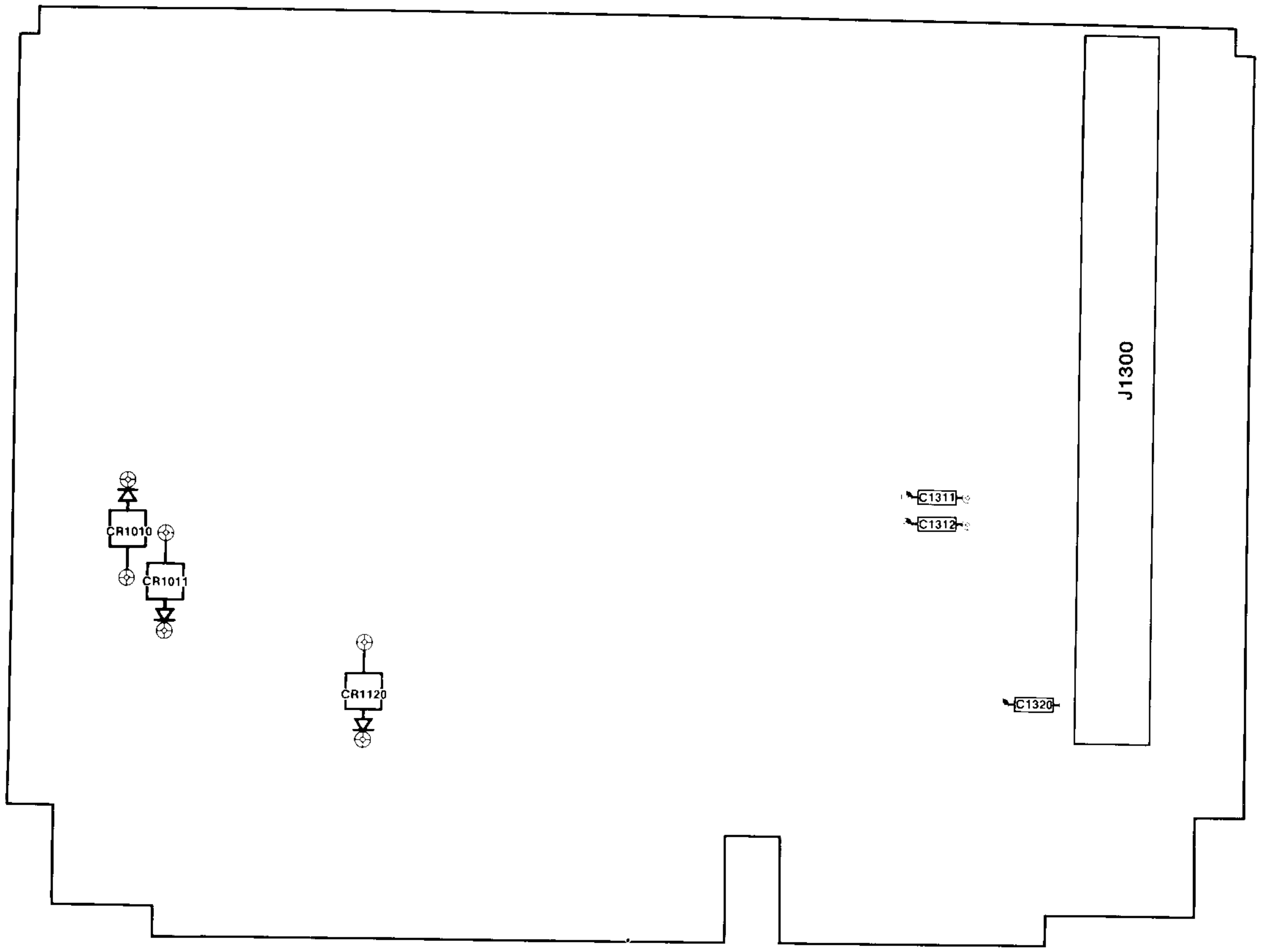


Figure FO-15. (A30) Main Interface Board Layout

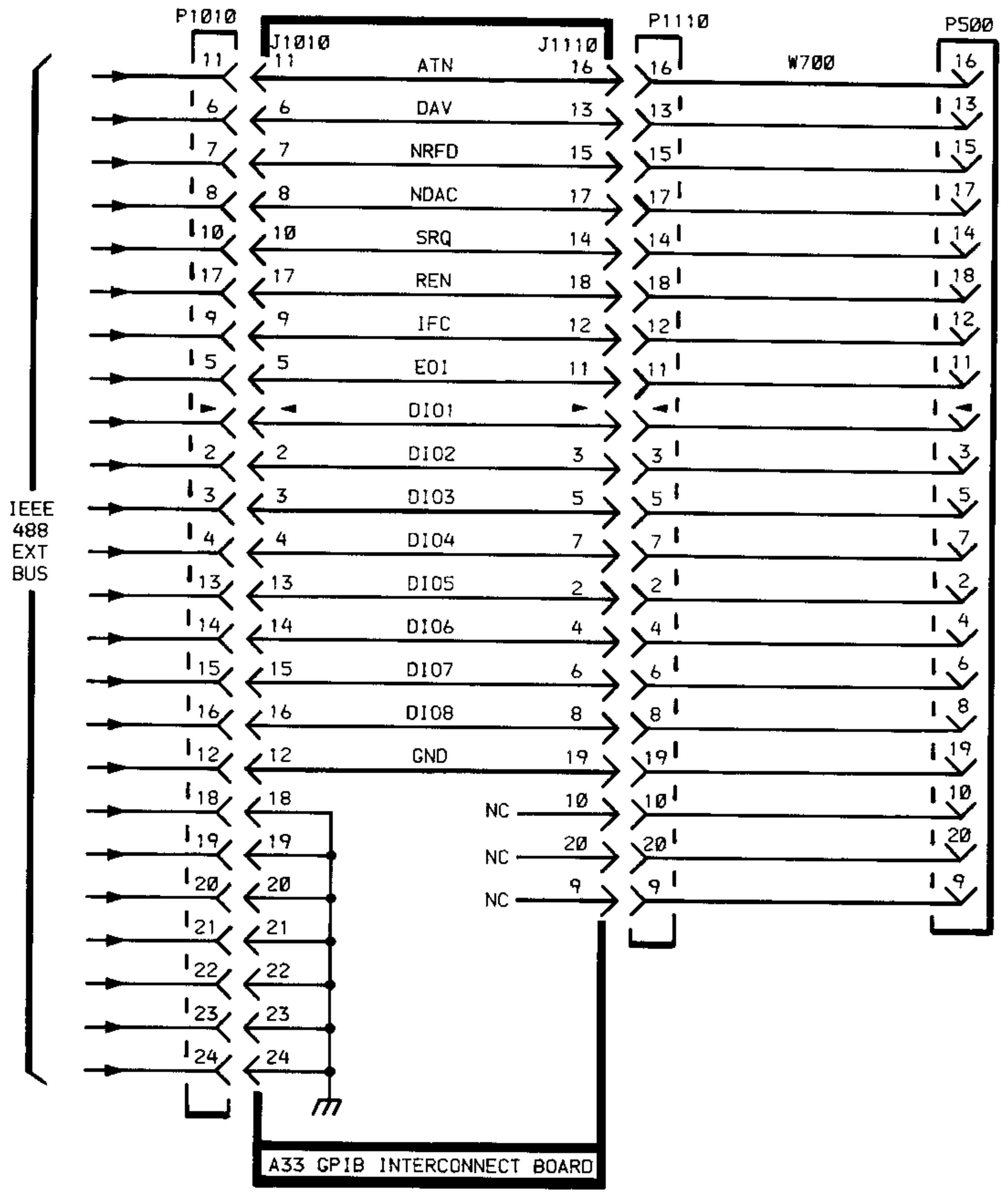
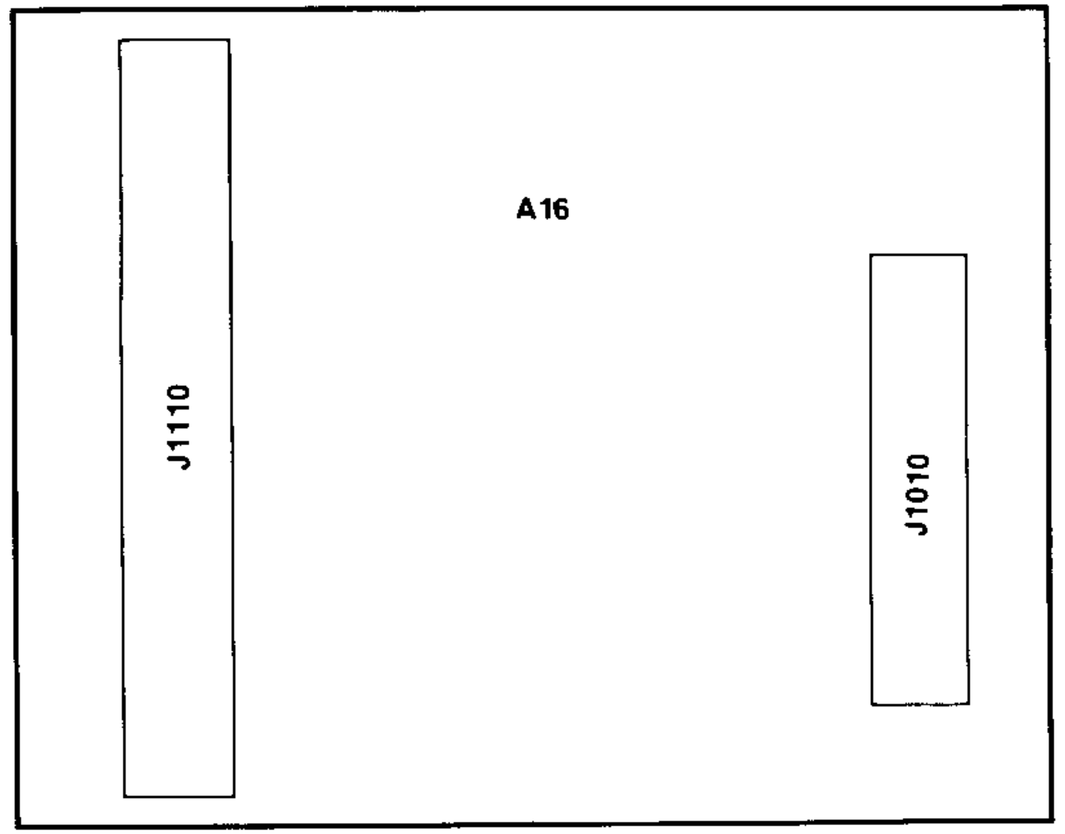


Figure FO-16. (A33) GPIB Interconnect Board Layout



REVERSE SIDE OF BOARD

Figure FO-17. (A16) GI GPIB Interconnect Board Layout

By Order of the Secretary of the Army:

JOHN A. WICKHAM, JR.
General, United States Army
Chief of Staff

Official:

R.L. DILWORTH
Brigadier General, United States Army
The Adjutant General

DISTRIBUTION:
To be distributed in accordance with DA Form 12-51 literature requirements for TS-4084/G.

*U.S. GOVERNMENT PRINTING OFFICE: 1993-342-421/81206

These are the instructions for sending an electronic 2028

The following format must be used if submitting an electronic 2028. The subject line must be exactly the same and all fields must be included; however only the following fields are mandatory: 1, 3, 4, 5, 6, 7, 8, 9, 10, 13, 15, 16, 17, and 27.

From: “Whomever” <whomever@wherever.army.mil>
To: 2028@redstone.army.mil

Subject: DA Form 2028

1. ***From:*** Joe Smith
2. *Unit:* home
3. ***Address:*** 4300 Park
4. ***City:*** Hometown
5. ***St:*** MO
6. ***Zip:*** 77777
7. ***Date Sent:*** 19–OCT–93
8. ***Pub no:*** 55–2840–229–23
9. ***Pub Title:*** TM
10. ***Publication Date:*** 04–JUL–85
11. *Change Number:* 7
12. *Submitter Rank:* MSG
13. ***Submitter FName:*** Joe
14. *Submitter MName:* T
15. ***Submitter LName:*** Smith
16. ***Submitter Phone:*** 123–123–1234
17. ***Problem:*** **1**
18. *Page:* 2
19. *Paragraph:* 3
20. *Line:* 4
21. *NSN:* 5
22. *Reference:* 6
23. *Figure:* 7
24. *Table:* 8
25. *Item:* 9
26. *Total:* 123
27. ***Text:***

This is the text for the problem below line 27.

RECOMMENDED CHANGES TO PUBLICATIONS AND BLANK FORMS For use of this form, see AR 25–30; the proponent agency is ODISC4.	Use Part II (*reverse*) for Repair Parts and Special Tool Lists (RPSTL) and Supply Catalogs/ Supply Manuals (SC/SM)	DATE 8/30/02
TO: (*Forward to proponent of publication or form)(Include ZIP Code)* Commander, U.S. Army Aviation and Missile Command ATTN: AMSAM–MMC–MA–NP Redstone Arsenal, AL 35898	FROM: (*Activity and location)(Include ZIP Code)* MSG, Jane Q. Doe 1234 Any Street Nowhere Town, AL 34565	

PART 1 – ALL PUBLICATIONS (EXCEPT RPSTL AND SC/SM) AND BLANK FORMS

PUBLICATION/FORM NUMBER	DATE	TITLE
TM 9–1005–433–24	16 Sep 2002	Organizational, Direct Support, And General Support Maintenance Manual for Machine Gun, .50 Caliber M3P and M3P Machine Gun Electrical Test Set Used On Avenger Air Defense Weapon System

ITEM NO.	PAGE NO.	PARA–GRAPH	LINE NO. *	FIGURE NO.	TABLE NO.	RECOMMENDED CHANGES AND REASON
1	WP0005 PG 3		2			Test or Corrective Action column should identify a different WP number.

EXAMPLE

** Reference to line numbers within the paragraph or subparagraph.*

TYPED NAME, GRADE OR TITLE	TELEPHONE EXCHANGE/ AUTOVON, PLUS EXTENSION	SIGNATURE
MSG, Jane Q. Doe, SFC	788–1234	

TO: (*Forward direct to addressee listed in publication*)	**FROM:** (*Activity and location) (Include ZIP Code)*	**DATE**
Commander, U.S. Army Aviation and Missile Command ATTN: AMSAM–MMC–MA–NP Redstone Arsenal, AL 35898	MSG, Jane Q. Doe 1234 Any Street Nowhere Town, AL 34565	8/30/02

PART II – REPAIR PARTS AND SPECIAL TOOL LISTS AND SUPPLY CATALOGS/SUPPLY MANUALS

PUBLICATION NUMBER	DATE	TITLE

PAGE NO.	COLM NO.	LINE NO.	NATIONAL STOCK NUMBER	REFERENCE NO.	FIGURE NO.	ITEM NO.	TOTAL NO. OF MAJOR ITEMS SUPPORTED	RECOMMENDED ACTION

PART III – REMARKS (*Any general remarks or recommendations, or suggestions for improvement of publications and blank forms. Additional blank sheets may be used if more space is needed.)*

TYPED NAME, GRADE OR TITLE	TELEPHONE EXCHANGE/AUTOVON, PLUS EXTENSION	SIGNATURE
MSG, Jane Q. Doe, SFC	788–1234	

RECOMMENDED CHANGES TO PUBLICATIONS AND BLANK FORMS For use of this form, see AR 25–30; the proponent agency is ODISC4.	Use Part II (*reverse*) for Repair Parts and Special Tool Lists (RPSTL) and Supply Catalogs/ Supply Manuals (SC/SM)	DATE
TO: (*Forward to proponent of publication or form)(Include ZIP Code)* Commander, U.S. Army Aviation and Missile Command ATTN: AMSAM-MMC-MA-NP Redstone Arsenal, AL 35898	FROM: (*Activity and location)(Include ZIP Code)*	

PART 1 – ALL PUBLICATIONS (EXCEPT RPSTL AND SC/SM) AND BLANK FORMS

PUBLICATION/FORM NUMBER	DATE	TITLE

ITEM NO.	PAGE NO.	PARA–GRAPH	LINE NO. *	FIGURE NO.	TABLE NO.	RECOMMENDED CHANGES AND REASON

** Reference to line numbers within the paragraph or subparagraph.*

TYPED NAME, GRADE OR TITLE	TELEPHONE EXCHANGE/ AUTOVON, PLUS EXTENSION	SIGNATURE

TO: (*Forward direct to addressee listed in publication*) Commander, U.S. Army Aviation and Missile Command ATTN: AMSAM-MMC-MA-NP Redstone Arsenal, AL 35898	**FROM:** (*Activity and location) (Include ZIP Code)*	**DATE**

PART II – REPAIR PARTS AND SPECIAL TOOL LISTS AND SUPPLY CATALOGS/SUPPLY MANUALS

PUBLICATION NUMBER	DATE	TITLE

PAGE NO.	COLM NO.	LINE NO.	NATIONAL STOCK NUMBER	REFERENCE NO.	FIGURE NO.	ITEM NO.	TOTAL NO. OF MAJOR ITEMS SUPPORTED	RECOMMENDED ACTION

PART III – REMARKS (*Any general remarks or recommendations, or suggestions for improvement of publications and blank forms. Additional blank sheets may be used if more space is needed.)*

TYPED NAME, GRADE OR TITLE	TELEPHONE EXCHANGE/AUTOVON, PLUS EXTENSION	SIGNATURE

The Metric System and Equivalents

Linear Measure

1 centimeter = 10 millimeters = .39 inch
1 decimeter = 10 centimeters = 3.94 inches
1 meter = 10 decimeters = 39.37 inches
1 dekameter = 10 meters = 32.8 feet
1 hectometer = 10 dekameters = 328.08 feet
1 kilometer = 10 hectometers = 3,280.8 feet

Weights

1 centigram = 10 milligrams = .15 grain
1 decigram = 10 centigrams = 1.54 grains
1 gram = 10 decigram = .035 ounce
1 decagram = 10 grams = .35 ounce
1 hectogram = 10 decagrams = 3.52 ounces
1 kilogram = 10 hectograms = 2.2 pounds
1 quintal = 100 kilograms = 220.46 pounds
1 metric ton = 10 quintals = 1.1 short tons

Liquid Measure

1 centiliter = 10 milliters = .34 fl. ounce
1 deciliter = 10 centiliters = 3.38 fl. ounces
1 liter = 10 deciliters = 33.81 fl. ounces
1 dekaliter = 10 liters = 2.64 gallons
1 hectoliter = 10 dekaliters = 26.42 gallons
1 kiloliter = 10 hectoliters = 264.18 gallons

Square Measure

1 sq. centimeter = 100 sq. millimeters = .155 sq. inch
1 sq. decimeter = 100 sq. centimeters = 15.5 sq. inches
1 sq. meter (centare) = 100 sq. decimeters = 10.76 sq. feet
1 sq. dekameter (are) = 100 sq. meters = 1,076.4 sq. feet
1 sq. hectometer (hectare) = 100 sq. dekameters = 2.47 acres
1 sq. kilometer = 100 sq. hectometers = .386 sq. mile

Cubic Measure

1 cu. centimeter = 1000 cu. millimeters = .06 cu. inch
1 cu. decimeter = 1000 cu. centimeters = 61.02 cu. inches
1 cu. meter = 1000 cu. decimeters = 35.31 cu. feet

Approximate Conversion Factors

To change	*To*	*Multiply by*	*To change*	*To*	*Multiply by*
inches	centimeters	2.540	ounce-inches	Newton-meters	.007062
feet	meters	.305	centimeters	inches	.394
yards	meters	.914	meters	feet	3.280
miles	kilometers	1.609	meters	yards	1.094
square inches	square centimeters	6.451	kilometers	miles	.621
square feet	square meters	.093	square centimeters	square inches	.155
square yards	square meters	.836	square meters	square feet	10.764
square miles	square kilometers	2.590	square meters	square yards	1.196
acres	square hectometers	.405	square kilometers	square miles	.386
cubic feet	cubic meters	.028	square hectometers	acres	2.471
cubic yards	cubic meters	.765	cubic meters	cubic feet	35.315
fluid ounces	milliliters	29,573	cubic meters	cubic yards	1.308
pints	liters	.473	milliliters	fluid ounces	.034
quarts	liters	.946	liters	pints	2.113
gallons	liters	3.785	liters	quarts	1.057
ounces	grams	28.349	liters	gallons	.264
pounds	kilograms	.454	grams	ounces	.035
short tons	metric tons	.907	kilograms	pounds	2.205
pound-feet	Newton-meters	1.356	metric tons	short tons	1.102
pound-inches	Newton-meters	.11296			

Temperature (Exact)

°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

PIN: 061365-000