INSTRUCTION MANUAL

FFT ANALYZER

MODEL FAE2000

Second Edition

KIKUSUI ELECTRONICS CORPORATION

(KIKUSUI PART NO. Z1-471-020)

Power Requirements of this Product

Power requirements of this product have been changed and the relevant sections of the Operation Manual should be revised accordingly.
(Revision should be applied to items indicated by a check mark ☑.)

☐ Input voltage

The input voltage of this product is ________ VAC,
and the voltage range is ________ to ________ VAC. Use the product within this range only.

☐ Input fuse

The rating of this product's input fuse is ________A, ________VAC, and ________.

WARNING

- To avoid electrical shock, always disconnect the AC power cable or turn off the switch on the switchboard before attempting to check or replace the fuse.
- Use a fuse element having a shape, rating, and characteristics suitable for this product. The use of a fuse with a different rating or one that short circuits the fuse holder may result in fire, electric shock, or irreparable damage.

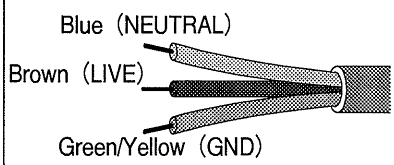
☐ AC power cable

The product is porvided with AC power cables described below. If the cable has no power plug, attach a power plug or crimp-style terminals to the cable in accordance with the wire colors specified in the drawing.

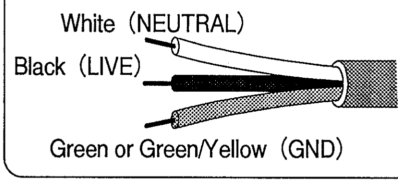
WARNING

- The attachment of a power plug or crimp-style terminals must be carried out by qualified personnel.

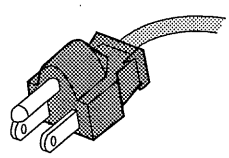
☐ Without a power plug



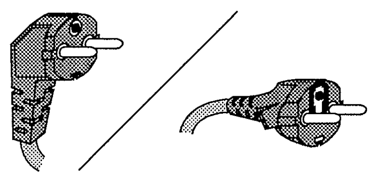
☐ Without a power plug



☐ Plugs for USA



☐ Plugs for Europe



☐ Provided by Kikusui agents

Kikusui agents can provide you with suitable AC power cable.
For further information, contact your Kikusui agent.

☐ Another Cable ________________________________

 Kikusui Part No. Z9-000-027 IB001681

CONTENTS

CHAPTER 1. OVERVIEW

The FAE2000 Portable FFT Analyzer is a single-channel input, 20 kHz, 12-bit analyzer for easy use not only in the laboratory but on the production line or in the field. The basic purpose of this analyzer is to measure time waveform. Through various computations, the analyzer displays time waveform, spectra, and histograms, on a variety of scales. The triggering and averaging functions promise sophisticated measurement. Acting as a comparator, the analyzer can also judge target objects to determine their compliance with a given set of performance criteria.

The analyzer may be used anywhere, operating on either an AC or a DC power source. An optional battery unit attached to the FAE2000 body forms an analyzer system easy to use in the field. An optional printer prints out screens of measured data together with the date and time of day. This feature makes sorting the data easy and efficient.

Another option, GP-IB, allows various setpoints and data to be readily filed for later reference.

An acceleration sensor and a dedicated power supply (SP01-FAE) may be incorporated into the optional battery unit, printer unit, or battery printer unit. The combination makes it possible for a single, integrated system to measure vibration and other phenomena.

CHAPTER 2. PREPARING FOR USE

2.1 Power Supply

(1) Verifying and changing the supply voltage

The AC supply voltage settings that may be used are as follows:

Supply voltage changeover switch	Voltage range	Frequency
115 V	85 V - 132 V	50, 60, 400 Hz
230 V	170 V - 264 V	50, 60, 400 Hz

The default setting is 115 V. Simply throwing the changeover switch changes the supply voltage. (Notice that turning the power supply on and off too quickly may result in a wrong setting for the analyzer.)

CAUTION: Before throwing the supply voltage changeover switch, be sure to turn off the POWER switch.

(2) Grounding

The power cable is equipped with a 3-pin plug, the round pin at the center serving as a ground terminal. When connecting the plug to an outlet with a grounding adaptor, make sure to connect to ground the ground wire (green) from the grounding adaptor or the ground terminal (GND) at the rear panel of the FAE2000.

(3) Inspecting and replacing the fuse

Two kinds of fuse are used with the FAE2000.

Purpose	Fuse used
For AC power supply	Miniature 2 A time-lag fuse
For DC power supply	Miniature 8 A time-lag fuse

Notes on replacement:

① Check that the fuse to be installed meets all specifications.

② Before inspecting or replacing the fuse, be sure to unplug the power cable.

(4) AC/DC changeover

The power supply may be switched between AC and DC with the POWER SOURCE switch at the rear panel of the FAE2000.

CAUTION: Before throwing the POWER SOURCE switch, be sure to turn off the POWER switch at the front panel. Do the same where the optional battery unit is attached.

2.2 Operating Environment

(1) The temperature must be between 0°C and 40°C, and the humidity must be 85% or lower.

(2) Avoid using the analyzer:

- near a device emitting a strong magnetic field or radiation;
- in the sun;
- in a dusty place; or
- in a location subject to mechanical vibration.

(3) Ensure good ventilation. Do not place an object(s) or a device(s) on or beside the analyzer. Obstructing vent holes will cause the temperature of the analyzer to rise because of self-generated heat.

(4) The analyzer has built-in countermeasures against noise propagation over the power cable. However, too much noise may overwhelm the built-in filtering capability. For use in any of the power supply environments described below, either employ a separate power source, or utilize an additional noise filter for noise removal. Running the analyzer on a battery is effective against noise.

Bad noise environments:

- A location susceptible to lightning or other causes of surge currents, power cuts or other power supply irregularities
- A location that exposes a power line to power cuts and large voltage fluctuations because of the frequent need for large starting currents and high power-on/off operations (e.g., for a turbine)
- A power line subjected to high power phase control (e.g., for dimmers)

(5) The external I/O cables and control cables should be double-shielding cables. Connect the outer shield to the ground terminal (GND) at the rear panel.

Recommended cables:

- 3D2W RG400 single-core cable
- EMI Okiflex eight-core cable (from Oki Densen) (These cables are protected against EMI.)

2.3 System Reset

Carry out system reset if the analyzer has developed trouble due to noise or for other reasons or if the fault persists after turning power off and then on again.

System reset

With the LOCAL key held down in the GP-IB section of the front panel, turn on the power. The screen will display:

"*** RAM CLEAR !! ***"

and the buzzer will sound for about 10 seconds. Now the parameter area in memory has been initialized by software.

(Initial setpoints)

- Time waveform Display
- Sense range: +30 dB
- Frequency range: 20 kHz
- Memory cleared (of stored panel setpoints and waveforms)

CHAPTER 3. SPECIFICATIONS OF FAE2000

3.1 Display

o Analyzed items for display	Time waveform, spectrum (magnitude, phase), histograms	
o Display	Raster scan CRT, 320(H) x 200(V) dots, 86(H) x 56(V) mm (frame size)	
o Display system	Single screen display	
o Vertical cursor	Single cursor	For reading values on the X- and Y-axes
	Dual cursor	For finding the difference in energy between two points on the X- and Y-axes
	Harmonic cursors	For displaying up to the 11th harmonic, THD and THP
	With cursor turned off	Peak values read out
o Conversion of units	On X-axis	Hz, CPM, ORDER, EXT (for external sampling)
	On Y-axis	Set by the engineering unit (EU) key, changeable to /Hz
o Vertical axis	Time waveform	Magnified from 1x up to 16x; offset available
	Magnitude spectrum	Mangnified from 80 dB to 16 dB/FS; offset available for logarithmic display; magnified from 1x to 65536x for linear display
	Phase spectrum	1x, 2x, 4x, 8x magnification
	Histogram	1x, 2x, 4x, 8x, 16x magnification
o Horizontal axis	Time waveform	1x, 2x, 4x, 8x, 16x, 32x magnification; offset available
	Spectrum	Linear or logarithmic
o Scale	A scale is displayed by pressing the GRATI key.	

3.2 Input

- No. of input channels — 1
- Input method — Single ended
- Input impedance — 1 MΩ, 100 pF
- Input connection — AC, DC, GND (-3 dB at 0.5 Hz point for AC)
- Maximum input voltage — ±200 V
- Maximum input sensitivity — -115 dB

- Input ranges

Range	Effective value	Peak value	Sensi-tivity	Input con-nection	
30 dB	31.6 Vrms	44.7 V	-30 dB	AC/DC	
20 dB	10.0	14.1	-40	AC/DC	
10 dB	31.6	4.47	-50	AC/DC	
0 dB	1.00	1.41	-60	AC/DC	
-10 dB	316 mVrms	447 mV	-70	AC/DC	
-20 dB	100	141	-80	AC/DC	
-30 dB	31.6	44.7	-90	AC/DC	
-40 dB	10.0	14.1	-100	AC	
-50 dB	3.165	4.47	-110	AC	
-60 dB	1.00	1.41	-115	AC	

- Test signal — Square wave (0 - +1.41 V) at frequency of 4% of each frequency range
- Overload detection — Analog and digital detection used together. The OVERLOAD LED lights up and the buzzer sounds when the input signal exceeds 93% of the input range, or when an input signal outside the frequency range exceeds 125% of the input range.

3.3 Trigger

o Trigger mode	Free Run, Armed (single shot trigger), Auto Armed (multiple trigger)
o Trigger source	Input signal (internal trigger), external trigger signal (external trigger)
o Trigger slope	Leading edge, trailing edge, external trigger signal edges (leading and trailing)
o Trigger levels	15 points (+7/8, +6/8, +5/8, +4/8, +3/8, +2/8, +1/8, 0, -1/8, -2/8, -3/8, -4/8, -5/8, -6/8, -7/8 of full scale of the input range)
o Trigger position	+512 to -512 (step-by-step setting)
o External trigger input	TTL level input, fan-in 1

3.4 Analyzer

- Sampling points — 512 per frame
- Frequency ranges

Frequency range	Frame time	Anti-aliasing filter
20 kHz	10 ms	20 kHz
10	20	10
5	40	5
2	100	2
1	200	1
500 Hz	400	500 Hz
200	1 s	200
100	2	100
50	4	50
20	10	20
10	20	10
5	40	10
2	100	10
1	200	10

- Frequency resolution — 1/200 of each frequency range
- No. of analyzed points — 512 points for the time domain, 201 points (DC + 200 lines) for the frequency domain, 128 points for histograms
- Real-time frequency — 200 Hz max.
- Sampling frequency — 2.56 times the frequency range, or an external sampling clock (51.2 kHz max.)
- Anti-aliasing filter — Either set for each of the frequency ranges for analysis (fixed to 10 Hz for ranges lower than 10 Hz); or the filter is turned off.
- A/D converter — 12-bit type

- Dynamic range — Over 60 dB (+30 to -50 dB range); Over 55 dB (-60 dB range)
- Magnitude accuracy — ±0.5 dB max.
- Windows — Rectangular, hanning, flattop
- Average items and averaging modes

Average item	Averaging mode		
	Arithmetic mean average	Exponential average	Peak hold
Time waveform	o	o	–
Magnitude spectrum	o	o	o
Histogram	o	o	–

- Averaging count — 2, 4, 8, ..., 8192
- Average control — Start, stop, continuous
- Computations — Addition, subtraction, (measured data) ± (stored data), differentiation, double differentiation, integration, double integration (for magnitude spectrum only)

3.5 Memory

o Display data memory	Can store and recall data for one display. (Up to 40 with optional memory)
o Panel condition memory	Can store and recall four panel-setting conditions (comparator area included but menu cursor position excluded). (Up to 10 with optional memory)
o Panel memory	Panel conditions (comparator area included) in effect when power was cut off are stored. The same conditions go into effect when power is restored.
o Memory battery back up	Approximately 1 month

3.6 Comparator

o Manner of judgment	Up to 10 rectangular comparator areas are used, with one of the level, peak and Partial overall methods selected for judgment by comparison.
o No. of settings for judgment	Four (i.e., the number of comparator areas in effect when the panel conditions were stored) are stored in panel condition memory.
o Display of judgment	GO or NG displayed on screen/LED
o Output of judgment	BUSY, GO or NG signal output by relay
o Judgment start input	A judgment start command (TTL) may be input from the outside.

o Data output and control input/output

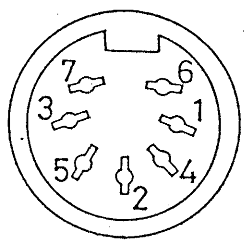
- Composite video output	Compatible with a non-interlace 320(H) x 200(V) dot display, 1 V_{p-p} of output voltage at 75
- Comparator start input	Fan-in 1 for TTL input, started at trailing edge
- Comparator output	BUSY, GO or NG signal output by relay (relay capacity: 100 mA/50 V DC max.)
- External trigger signal input	Fan-in 1 for TTL input, 50 kHz max.
- External sampling clock input	Fan-in 1 for TTL input, 51.2 kHz max.
- Sampling clock output	Fan-out 2 for TTL output
- GP-IB interface	Optional

3.7 Connector Pin Arrangement

(1) Video output (VIDEO OUT)

Pin No.	Function
1	NC
2	Video signal output
3	NC
4	NC
5	NC
6	NC
7	Signal ground
Frame	Case ground

DIN connector pin arrangement (NC: not connected)



(The pin arrangement is the same as for comparator input/output and external trigger input.)

Compatible connector:

(JA:) TCP0576 (7-pin DIN connector, available from Hoshi Denki Manufacturing K.K.)

① General specifications

- Output signal system: Composite
- Data signal: 1 V_{p-p} (output impedance: 75 Ω)
- Horizontal synchronizing signal: 17.00 kHz
- Vertical synchronizing signal: 68.57 kHz
- Output connector: 7-pin DIN connector
- Compatible connector: TCP0576 (7-pin DIN connector, available from Hoshi Denki Manufacturing K.K.)

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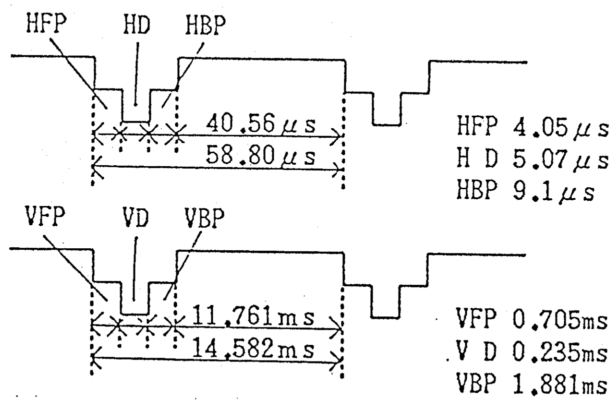
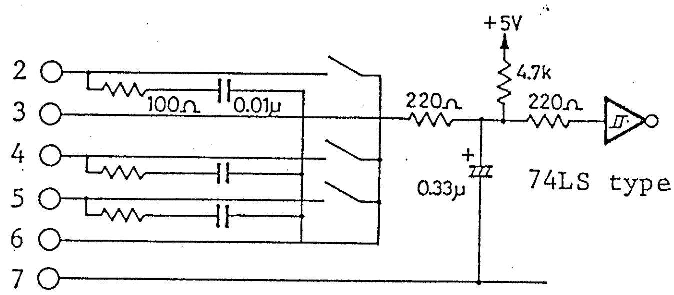
② Timing chart



(2) Comparator input/output (COMP OUT)

Pin No.	Function	Internal circuit
1	NC	
2	NG relay output	
3	START input	
4	GO relay output	
5	BUSY relay output	
6	Relay common	
7	Signal ground	
Frame	Case ground	

Compatible connector:

(JA:) TCP0576 (7-pin DIN connector, available from Hoshi Denki Manufacturing K.K.)

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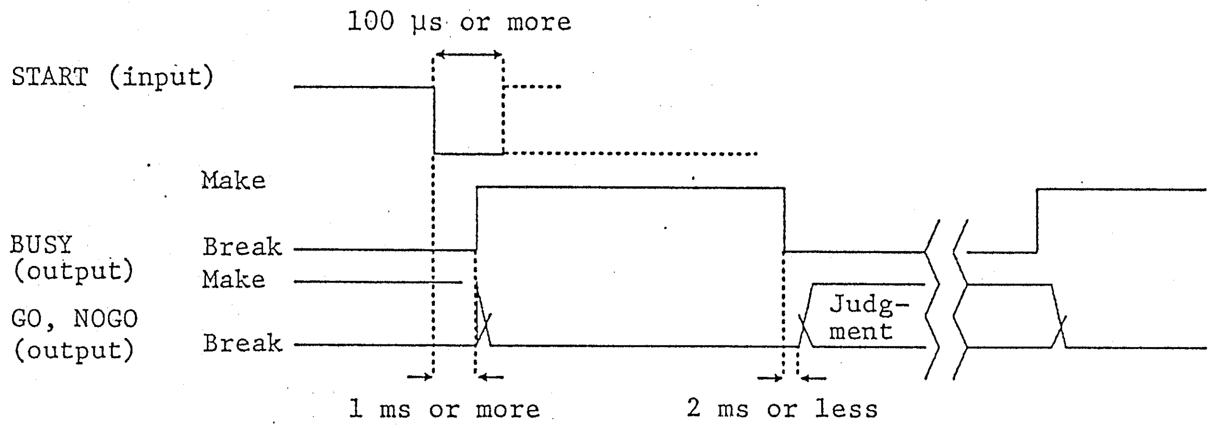
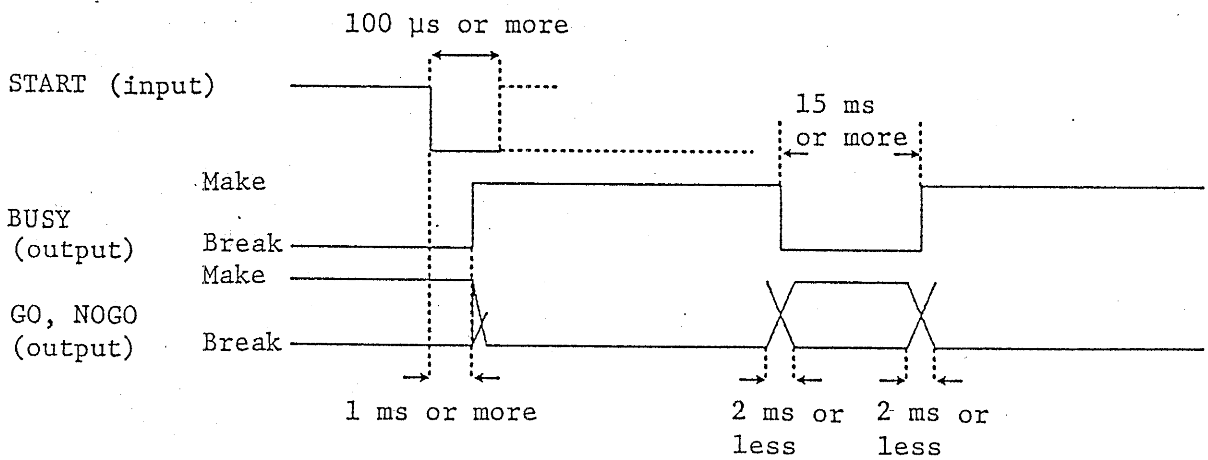
o When "SNGL" (single) is displayed in the MODE field of the COMP menu:



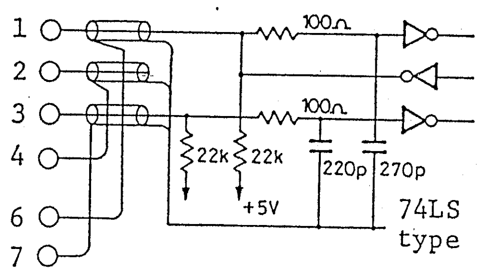
o When "FREE" is displayed in the MODE field of the COMP menu:



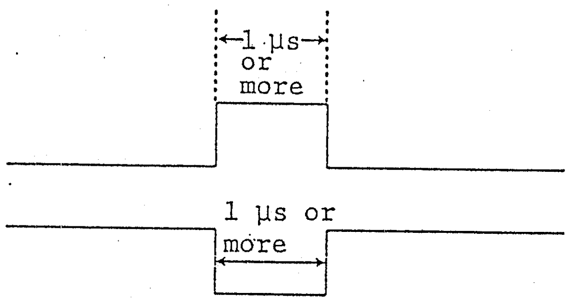
* The BUSY, GO and NG outputs are a relay output each, with inevitable variations in chattering and operating times. Each signal should be read in at least 1 ms after an edge is detected so that the variations may be accommodated.

* The START signal acts at a trailing edge. Do not input START when BUSY is in effect. To input START, supply a trailing edge with no chattering.

(3) External trigger input, external sampling input, and sampling clock output (EXTCLK EXTTRG)

Pin No.	Function	Internal circuit
1	External trigger input	
2	Sampling output	
3	External sampling clock input	
4	Signal ground (sampling clock output)	
5		
6	Signal ground (external trigger input)	
7	Signal ground (external sampling clock input)	
Frame	Frame ground	
Compatible connector: (JA:) TCP0576 (7-pin DIN connector, available from Hoshi Denki Manufacturing K.K.)		

o Pin No. 1: External trigger input (TTL), fan-in 1



Leading edge

Trailing edge

Either a leading edge or a trailing edge may be selected using the SLOPE field of the TRIG menu.

o Pin No. 2: Sampling output (TTL), fan-out 2; data is sampled at trailing edges.

o Pin No. 3: External sampling clock input (TTL) at trailing edge, 51.2 kHz max., fan-in 1

3.8 General Specifications

o Power supply	
- AC power source	85 - 132 V AC or 170 - 264 V AC, 50/60/400 Hz, 45 VA
- DC power source	11 - 15 V DC, 33 W
- Battery adaptor	The system operates for 2 to 3 hours on battery (BU01, BP01-FAE). The battery is rechargeable with the BC01-FAE battery charger.
o Operating temperature	0°C to 40°C, with relative humidity of less than 85%
o Storage temperature	-20°C to +65°C
o Dimensions	150(H) x 260(W) x 385(D) mm (handle and protrusions excluded)
o Net weight	Approximately 8 kg
o Accessories	
- Input cable	1
- Power cable	1
- DC power cable	1
- Fuse	1 for AC use (2 A), 1 for DC use (8 A)
- Connector	1 (7-pin DIN connector)
- Instruction manual	1

3.9 Optional Specifications

- IF01-FAE GP-IB interface

  This interface is incorporated in the FAE2000 and complies with IEEE488-1978. The functions include SH1, AH1, T6, L4, SR1, RL1, PP0, DC1, DT0, and C0.

- ES01-FAE memory/function unit
  - Memory to store data for 40 displays and 6 sets of panel conditions.
  - 1/3 octave band analysis and "A" weighting.
  - 3 dimensional display.
  - Zooming function (magnifications of 2, 4, 8, 16, 32 times).

- BU01-FAE battery unit

  This unit, installed under the FAE2000, allows it to operate anywhere on battery power.

- Capacity	12 V, 8.5 Ah
- Operating time	FAE2000 running for 2 to 3 hours (on fully charged battery)
- Charging	The unit, with the battery remaining inside, is charged by the BC01-FAE. The FAE2000 can operate on an AC power supply during the charging operation.
- Effective charging count	300 or more
- Operating temperature	0°C to 40°C, with relative humidity of less than 85%
- Storage temperature	-20°C to +50°C, with relative humidity of less than 85%

- Dimensions: 74(H) x 260(W) x 385(D) mm (protrusions excluded)
- Net weight: Approximately 6 kg

o PU01-FAE printer unit

This unit, installed under the FAE2000, allows display screens (including date, time of day, and counter values) and parameter lists to be printed out as hard copy.

- Copy size: 89 x 55 mm
- Printing time: Approximately 75 seconds per screen
- Printing paper: PP-123 (thermosensitive paper, printed in black, 122 mm in width)
- Printer life: Approximately 5800 screens
- Operating temperature: 0°C to 40°C, with relative humidity of less than 85%
- Storage temperature: -20°C to +65°C, with relative humidity of less than 85%
- Accessories: 1 roll of printing paper, 2 connection cables
- Dimensions: 74(H) x 260(W) x 385(D) mm (protrusions excluded)
- Net weight: Approximately 3.5 kg

o BP01-FAE battery/printer unit

This feature is a combination of the BU01-FAE and the PU01-FAE. The battery-and-printer combination is installed under the FAE2000 for use.

- Operating temperature: 0°C to 40°C, with relative humidity of less than 85%
- Storage temperature: -20°C to +50°C
- Accessories: 1 roll of printing paper, 2 connection cables

- Dimensions: 74(H) x 260(W) x 385(D) mm (protrusions excluded)
- Net weight: Approximately 6.5 kg

Refer to the descriptions of the BU01-FAE and PU01-FAE for the other items.

o PP-123 thermosensitive paper

A roll of this paper (printing paper for dedicated use with PU01, BP01-FAE) is put into the printer.

- Printing color: Black
- Dimensions: 112 mm(W) x 18 m (roll 40 mm across)
- Screen copy count: Approximately 200 screens

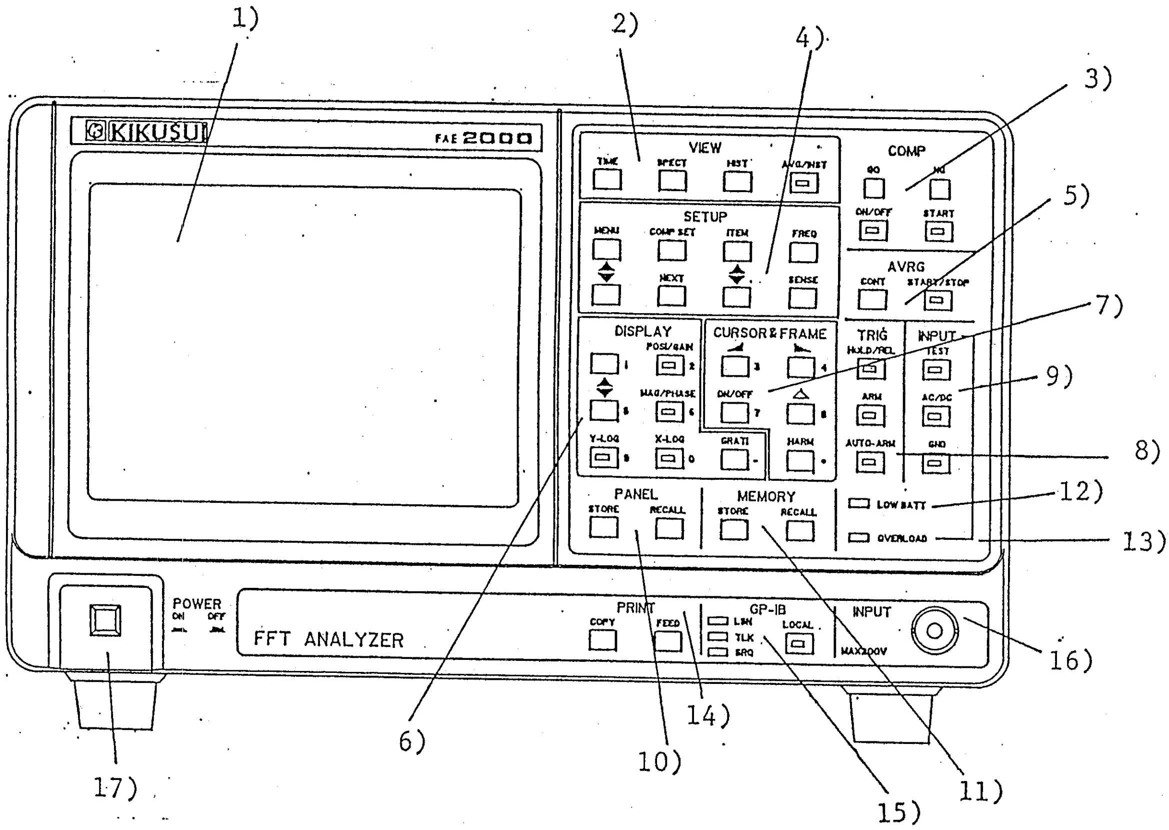
o BC01-FAE battery charger

Charges the battery while it remains in the subcase. The FAE2000 can continue to operate on an AC power source during the charging operation.

- Charging time: Approximately 6 hours
- Operating temperature: 0°C to 40°C, with relative humidity of less than 85%
- Storage temperature: -20°C to +65°C
- Supply voltage: 100 V AC ± 10%, 50/60 Hz, 40 VA
- Dimensions: 150(W) x 105(H) x 250(D) mm (protrusions excluded)
- Net weight: Approximately 5 kg
- Accessories:

Fuse (1 A)	1
Power cable	1
Charging cable	1
Instruction manual	1

CHAPTER 4. DESCRIPTION OF FRONT PANEL



1) Raster scan CRT
   Measuring conditions, scale values, cursor positions and other information are displayed on an 86 mm (H) x 56 mm (V) (4" diagonal) screen.

2) VIEW Section
   This section is used to select display functions.

[TIME]	:	Display time waveform
[SPEC]	:	Displays spectrums; allows magnitude or phase spectrum display to be selected by the use of the [MAG/PHASE] key in the DISPLAY section.
[HIST]	:	Displays histogram.
[AVG/INST]	:	Displays averaged or instantaneous data.

3) COMP Section
   This section is used to control the comparator and display compared results.

[ON/OFF]	:	Turns the comparator execution mode on and off.
[START]	:	Starts compare operation, allows the comparator to be started by admitting an input through the rear panel, and causes compared results and BUSY signal to be output by relay.

4) SETUP Section

This section is used to set up measuring conditions.

- [FREQ], [SENSE] : Simple fingertip operations select frequently used frequency range and sense range.
- MENU (Δ), (∇) : Select set items from the menus.
- [NEXT] : Selects sub-menus from each menu.
- ITEM (Δ), (∇) : Turn individual items on or off, and increase or decrease setpoints.
- [COMPSET] : Sets comparator areas and selects items in each menu.

5) AVRG Section

This section is used to perform averaging from twice to 8192 times.

- [START/STOP] : Starts averaging when pressed, and stops it when pressed again.
- [CONT] : Resumes suspended averaging.

6) DISPLAY Section

This section is used to specify how the display is to be provided.

- [POSI/GAIN] : Changes the offset for time waveform and spectrums (POSI), or changes the Y-axis full scale (GAIN).
- [X-LOG] : Turns the X-axis to a logarithmic scale for spectrums.
- [Y-LOG] : Turns the Y-axis to a logarithmic scale for spectrums.
- [GRATI] : Displays a graticule on the screen.
- [MAG/PHASE] : Displays magnitude (MAG) or phase (PHASE) spectrum. (This key is operable for spectrums only.)

7) CURSOR & FRAME Section

This section is used to control the cursor, harmonic, and time waveform frames.

- [ON/OFF] : Turns the cursor on and off. A peak value is displayed when the cursor is turned off.
- (◁), (▷) : With the cursor on, moves cursor horizontally; with the cursor off, moves the time waveform frame.
- (Δ) : Turn the sub-cursor on, and allows the difference between main cursor and sub-cursor on the X- and Y-axes to be displayed.
- [HARM] : Displays up to the 11th harmonic based on the peak frequency when the cursor is off, or displays up to the 11th harmonic based on the cursor when the cursor is on.

8) TRIG Section

This section is used to select the trigger mode

- [HOLD/REL] : Permits continuous measurement (REL), or stops data reception (HOLD).
- [ARM] : Waits for a single-shot trigger pulse, and enters a hold state when the pulse is activated.
- [AUTO-ARM] : Provides repeated trigger pulses.

9) INPUT Section
This section is used to select the input mode.
[TEST] : Provides an internal test signal.
[AC/DC] : Sets input connection (when AC -3dB at 0.5 Hz).
[GND] : Connects the input internally to ground.

10) PANEL Section
This section is used to store 4 panel conditions.
[STORE] : Stores data when used along with numeric keys.
[RECALL] : Recalls data when used along with numeric keys.

11) MEMORY Section
This section is used to store one group of measured data.

12) LOW BATT Indicator Lamp
Lights when the supply voltages (DC) becomes lower than normal.

13) OVERLOAD Indicator Lamp
Lights for 0.5 seconds even at instantaneous overload.

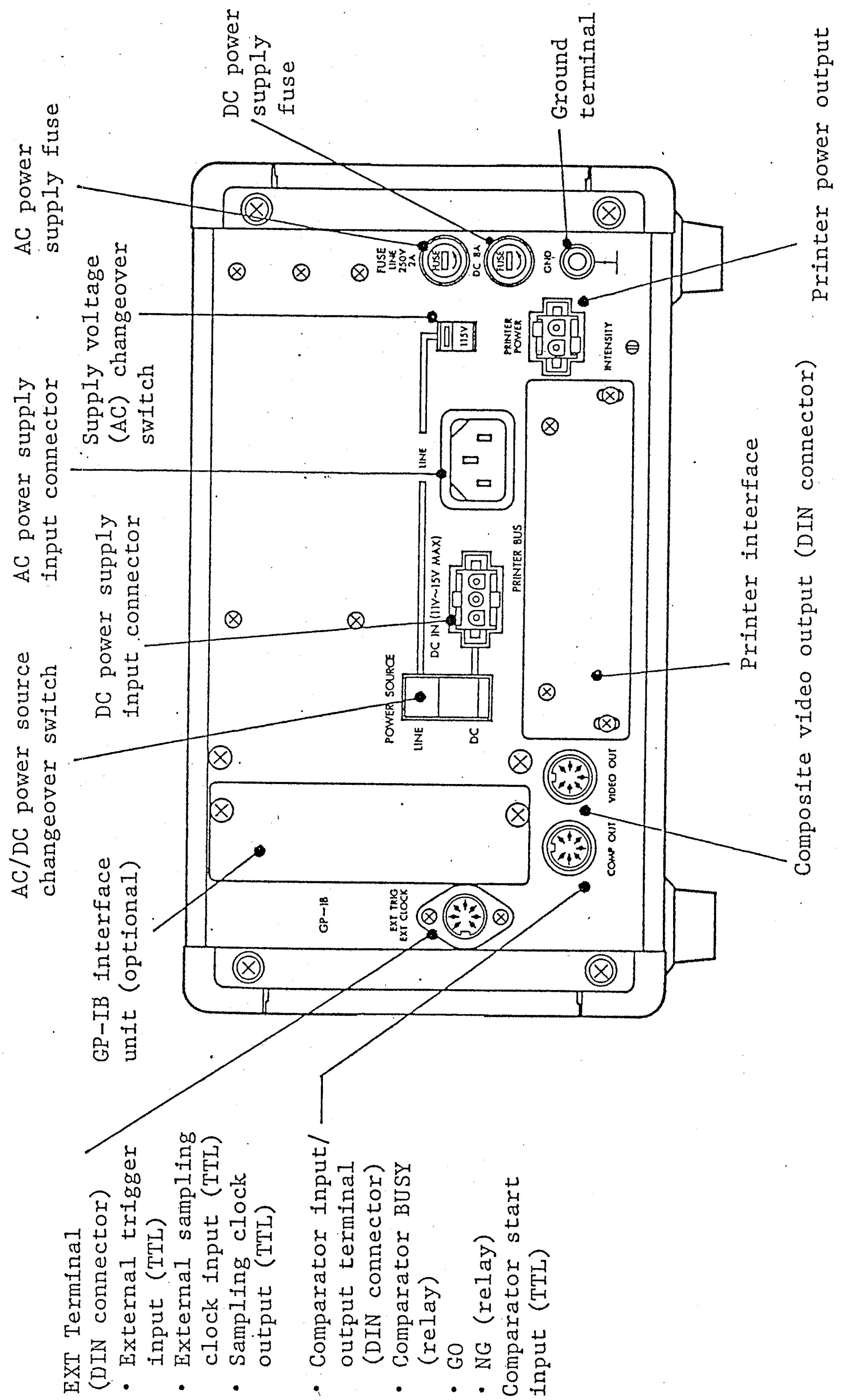
14) PRINT Section (optional)
This section is used to control the printer.
[COPY] : Copies the screen.
[FEED] : Feeds paper.

15) GP-IB Section (optional)
This section permits GP-IB control and display.

16) INPUT Terminal
This is a BNC connector that admits input voltages of up to ±200 V.

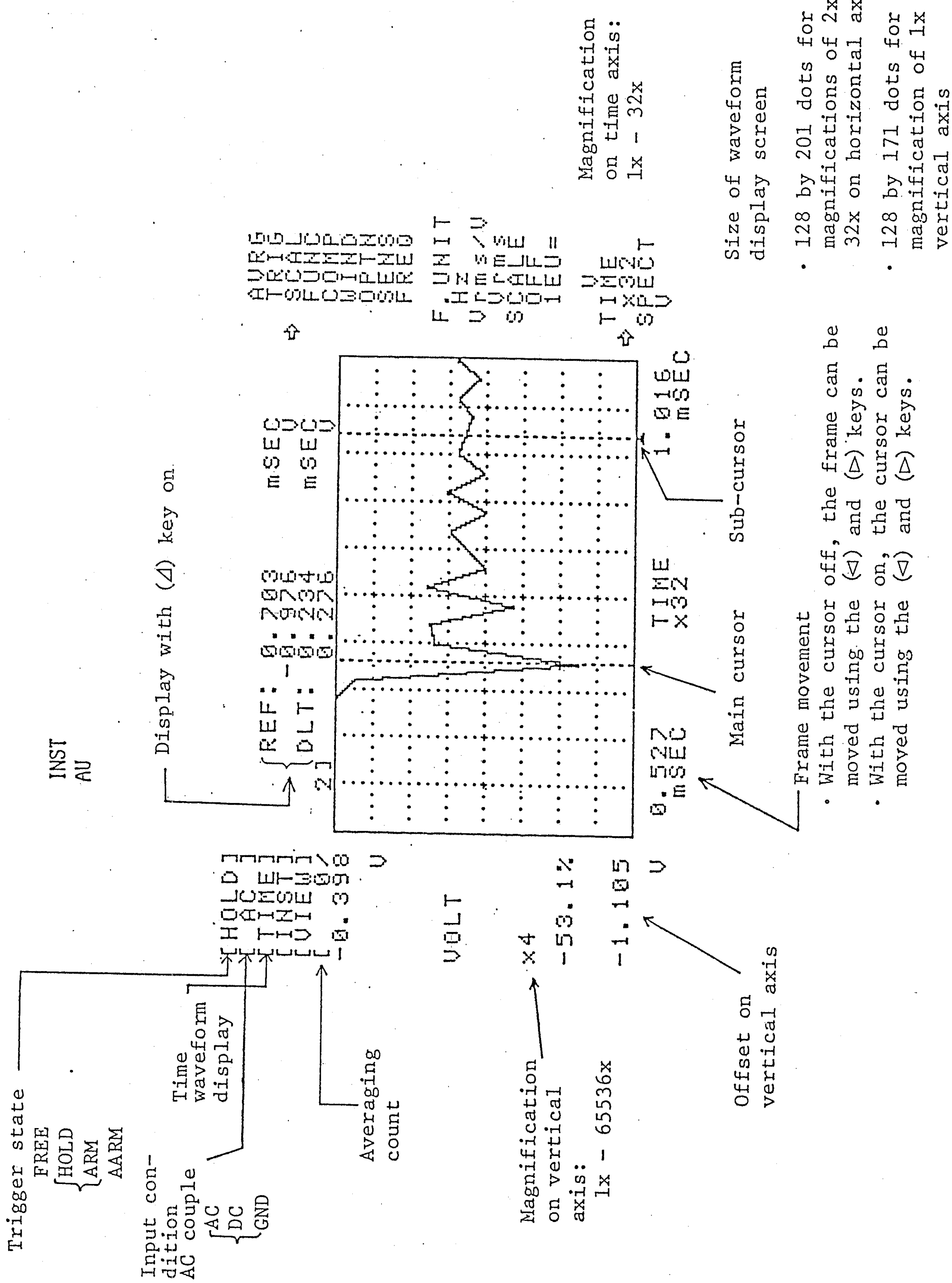
17) POWER Switch
- The FAE2000 operates from two power sources : AC and 12V DC. An optional battery unit allows the FAE2000 to operate wherever desired.
- A panel memory backup function allows measurement to be started upon power-up with the same panel condition as those in effect when power was last removed.

CHAPTER 5. DESCRIPTION OF REAR PANEL



CHAPTER 6. DESCRIPTION OF SCREENS

6.1 Example of Time Waveform Display



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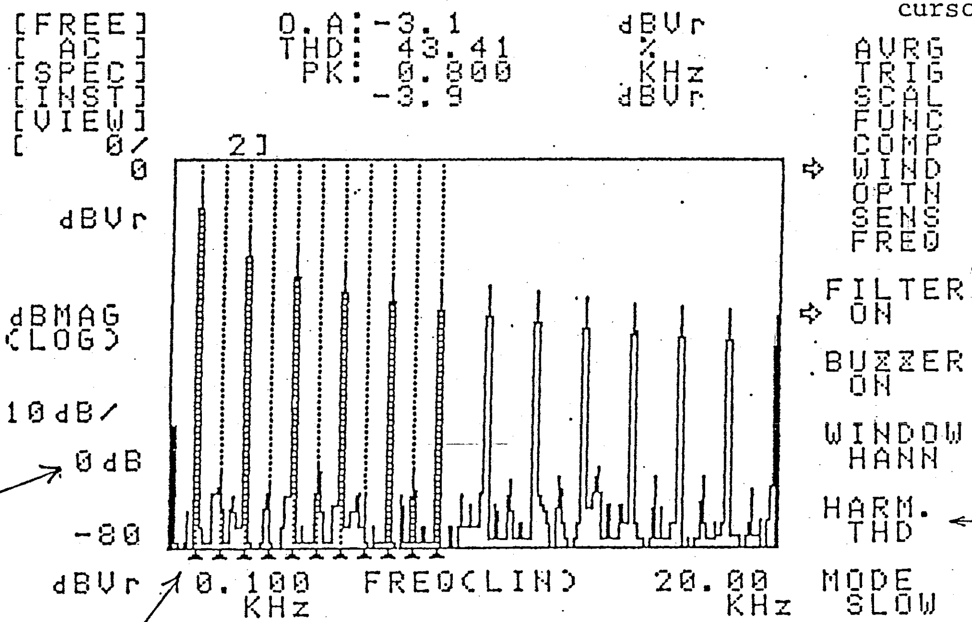
6.2 Example of MAG Spectrum Display

Overall display:
Effective for displaying MAG spectrums
- OVERALL: Effective values of all screens
- PARTIAL: Effective values between cursors



Display on vertical axis (LOG/LIN)

Division spacing
- 2dB/div
- 5dB/div
- 10dB/div

Offset amount of vertical axis

Selection of window
- Hanning
- Flat top
- Rectangular

THD or THP is selected and displayed (display available only with MAG spectrums).

Size of waveform display screen:
128 by 201 dots

Display on horizontal axis (LOG/LIN)

Harmonics marker (up to 11th):
In this example, peak values constitute fundamental frequency.
- With the cursor off, peak frequency is the fundamental frequency.
- With the cursor on, the main cursor frequency is the fundamental frequency.

(Harmonics are not displayed when the horizontal axis is logarithmic.)

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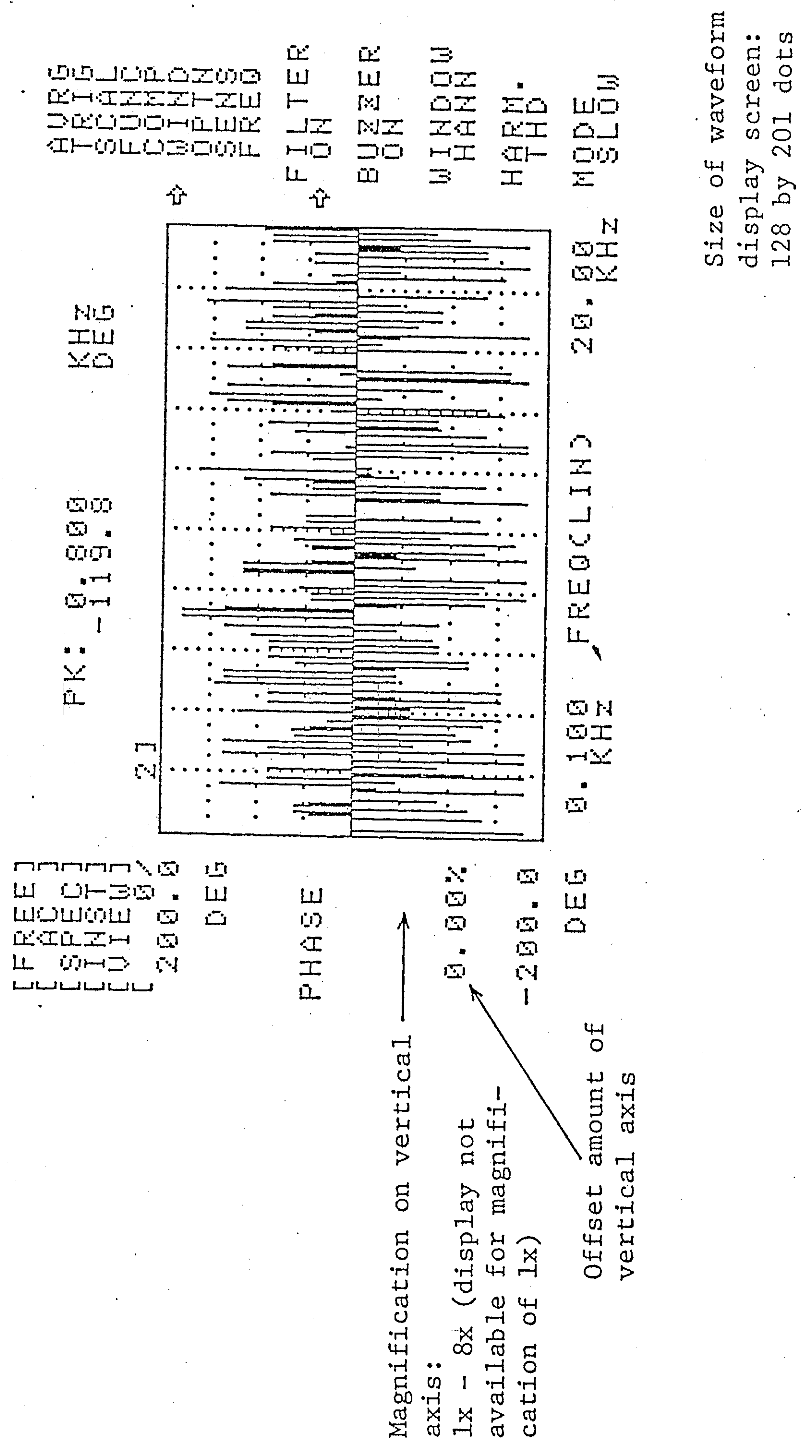
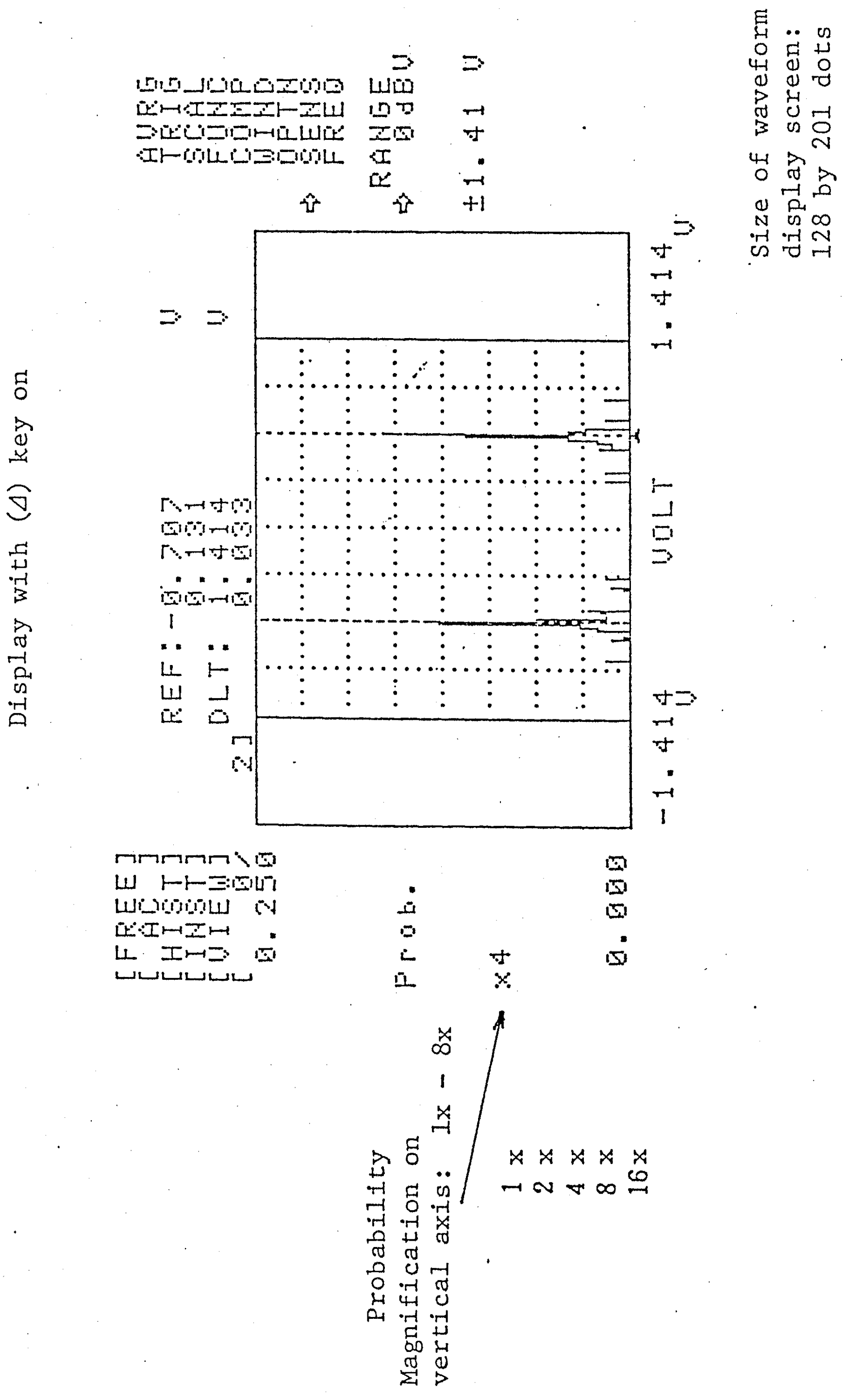
6.3 Example of Phase Spectrum Display



6.4 Example of Histogram Display

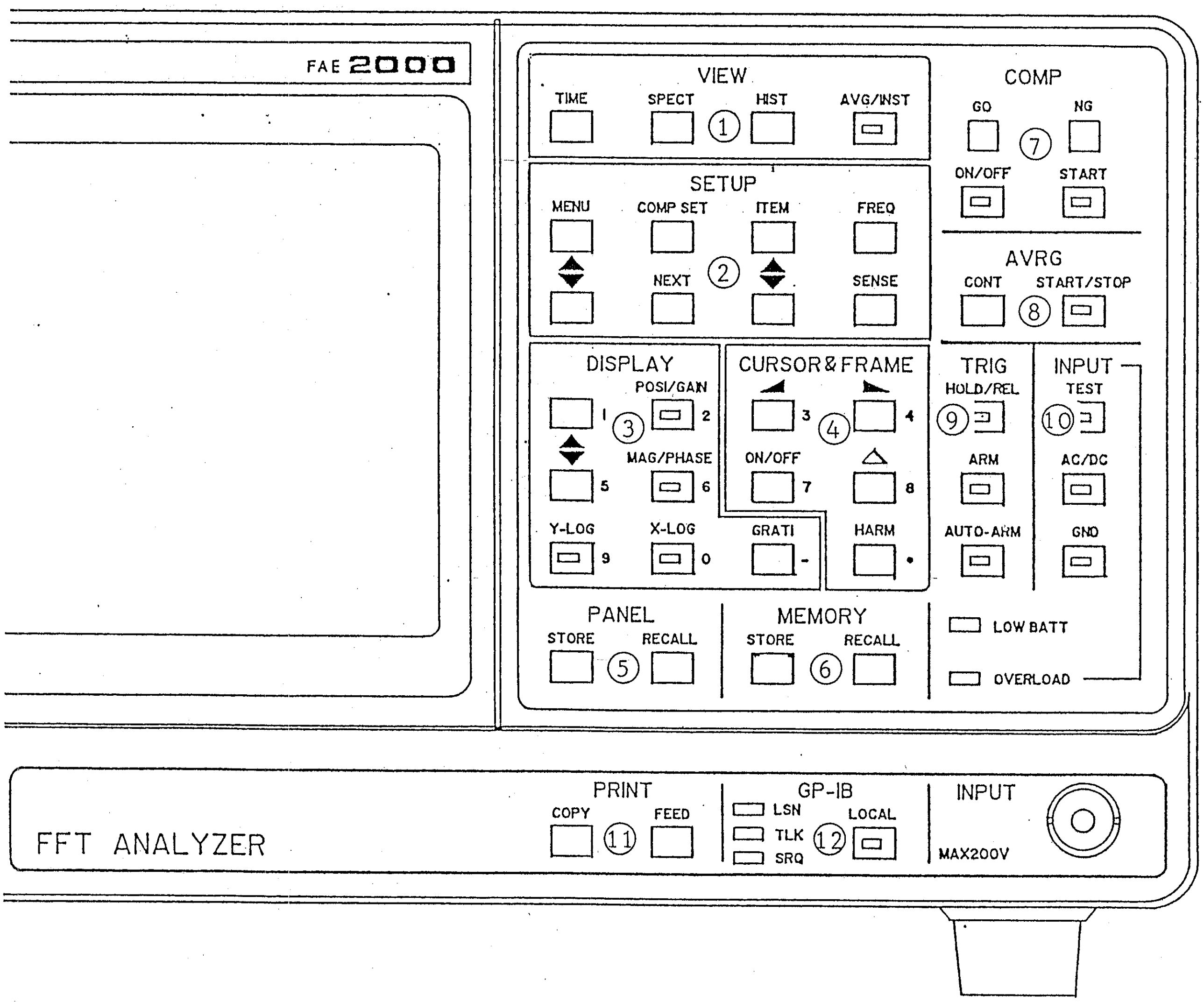


CHAPTER 7. PANEL OPERATION

7.1 Outline

At the control panel of the FAE2000, an operator views the data and menus displayed on the CRT, and presses the keys interactively to set various measuring conditions for analysis.
The paragraphs that follow describe what function each key provides, and how various conditions are set and reset with it. Read the descriptions carefully in order to operate the FAE2000 correctly.
The keys are functionally divided into 12 sections, such as the VIEW and SETUP sections (Fig. 7.1).
Paragraph 7.2, "Outline of the Sections" outlines each of the sections. Paragraph 7.3, "Using the Keys" explains how to use the keys in each section, and explains the key functions.
Depending on the set condition, the FAE2000 may not accept a change in an item, setpoint or screen. When an input is accepted, a short "beep" sound is emitted. When refused a long "beep" sound is emitted (with BUZZER of the WIND menu set to ON).

Note: A glowing LED on a key indicates that key's function is activated. A key shown with a slash (xx/xx) means that the left-hand function is active when the LED is lit.



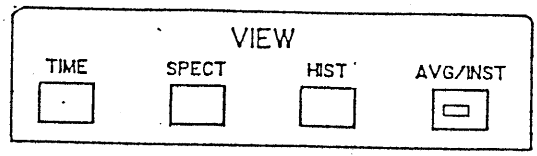
① VIEW section	② SETUP section
③ DISPLAY section	④ CURSOR & FRAME section
⑤ PANEL section	⑥ MEMORY section
⑦ COMP section	⑧ AVRG section
⑨ TRIG section	⑩ INPUT section
⑪ PRINT section	⑫ GP-IB section

Fig. 7.1 Front View

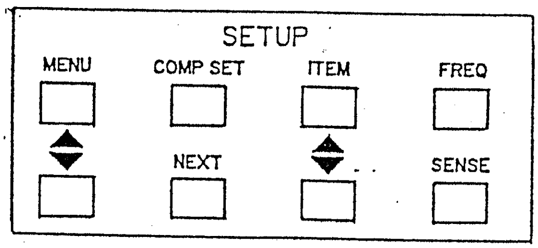
7.2 Outline of the Sections

Each of the sections is outlined below.

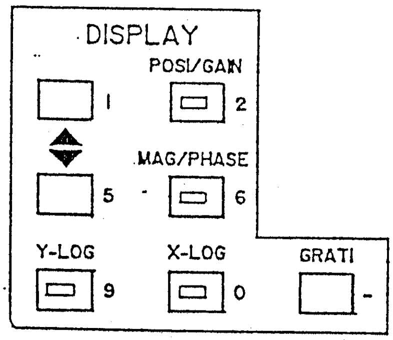
(1) VIEW section
This section selects waveform data for display on the CRT.



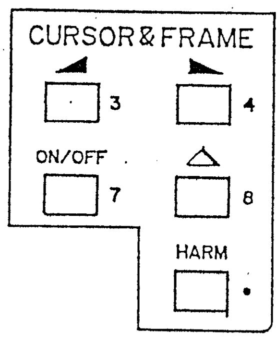
(2) SETUP section
This section selects the menus and specifies the items necessary to select and set various conditions and functions for measurement.



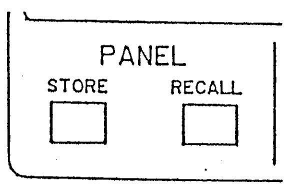
(3) DISPLAY section
This section makes waveform data into the desired shape on the CRT display.



(4) CURSOR & FRAME section
This section positions the cursor, moves frames of time waveform data, and turns harmonic power and distortion on and off.



(5) PANEL section
This section stores and recalls panel conditions set by keys.



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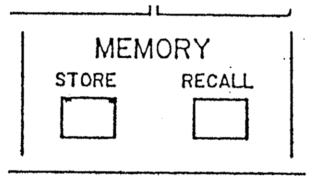
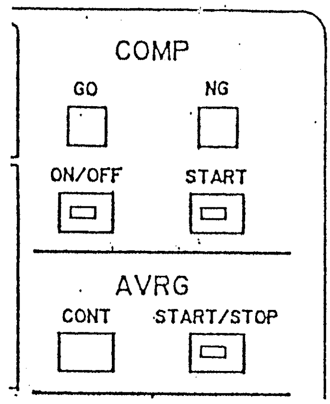
(6) MEMORY section
This section stores and recalls measured data.

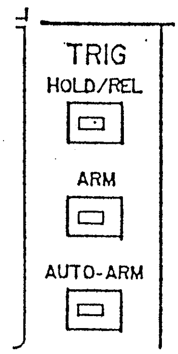


(7) COMP section
This section employs the comparator function.

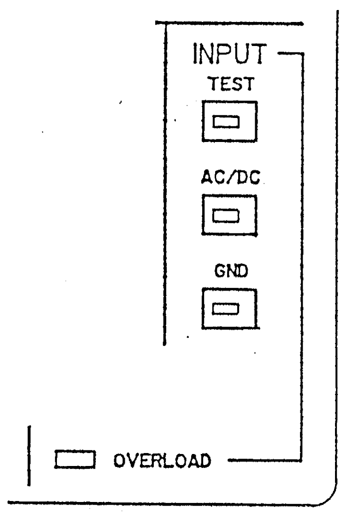


(8) AVRG section
This section controls the execution of averaging computations.

(9) TRIG section
This section activates the trigger.



(10) INPUT section
This section selects input signals.



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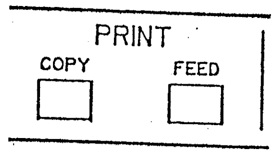
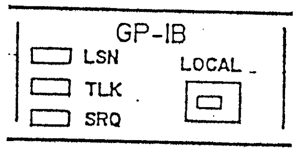
(11) PRINT section

This section controls the printer.



(12) GP-IB section

This is used when the FAE2000 is controlled by the GP-IB.

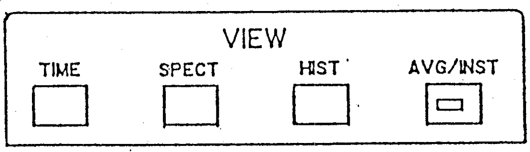


7.3. Using the Keys

How to use the keys in each section is explained below. The function of each key is also explained.

7.3.1 VIEW Section

The keys in this section are used to select waveform data for display on the CRT. The keys include:



TIME key : Displays a time waveform.

SPECT key : Displays a spectrum waveform.

HIST key : Displays a histogram waveform.

AVG/INST key: With the LED on, AVG is selected to display an average waveform; with the LED off, INST is selected to display an instantaneous waveform.

The waveform domain for the current display is indicated as [TIME], [SPEC] or [HIST] in the top left corner of the CRT screen. Indications [AVRG] and [INST] appear under the waveform domain indications for an average waveform display and an instantaneous waveform display, respectively.

The AVG key is inoperable when:

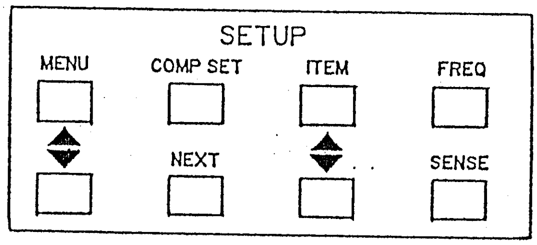
- The domain of the AVRG menu is not the same between the VIEW and SETUP sections;
- Averaging is not executed after power-up;
- The frequency range and sense range in effect when averaging was performed do not match those currently displayed; or
- A phase spectrum is being displayed.

The AVG key is nonetheless operable when:

Averaging of a time waveform is either under way or completed. At this time, the AVG key is operable even if the domain in the VIEW section is not the time waveform. The waveform displayed here is a magnitude spectrum, phase spectrum or histogram in average time waveform. (See (12) in 8.1, "Measuring the Time Waveform.")

7.3.2 SETUP Section

The keys in this section select menus and specify the necessary items on the CRT screen.



A menu is selected with the MENU (▲▼) keys.
The selected menu is the one pointed to by an arrow (→).
The arrow is moved upward by pressing the MENU (▲) key, and downward by pressing the MENU (▼) key.

```
→ AVRG
  TRIG
  SCAL
  FUNC
  COMP
  WIND
  OPTN
  SENS
  FREQ

  NUMBER
→   2

  DOMEIN
  SPEC

  MODE
  SUMN
```

The COMPSET and NEXT keys select an item in the menu selected. The selected item is the one pointed to by the arrow. The arrow is moved upward with the COMSET key, and downward with the NEXT key.
The ITEM (▲▼) keys are used to increment, decrement or change the contents of the selected item.
Of the menus, the frequently used FREQ and SENS menus are selected by pressing the FREQ and SENS keys respectively.
The MENU (▲▼), NEXT, and ITEM (▲▼) keys repeat the assigned operation when held down.
Each of the selected menus and the items in them is described below in detail.

7.3.2.1 AVRG Menu

The AVRG menu allows the averaging count, averaging domain and averaging mode to be specified. Execution of averaging is controlled by the keys in the AVRG section.

```
→ AVRG
  TRIG
  SCAL
  FUNC
  COMP
  WIND
  OPTN
  SENS
  FREQ

  NUMBER
→    2

  DOMEIN
  SPEC

  MODE
  SUMN
```

a) NUMBER
Specify the averaging count by selecting one of the numbers 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048, 4096, or 8192.

b) DOMAIN

Select a domain in which to perform averaging.

- TIME: Time waveform averaging
- HIST: Histogram averaging
- SPEC: Magnitude spectrum averaging

c) MODE

Select an averaging mode from among the following

- SUMN: Arithmetic mean (sum natural)
- EXP : Exponential average
- PEAK: Peak hold

* Notice that averaging is not be possible with some domain types (see Table 7.1).

(1) Explanation of averaging modes

o SUMN

Arithmetic mean averages (sum natural)are calculated. Averaging is performed up to the count specified in NUMBER.

$$A = \frac{D_1 + D_2 + \cdots + D_x + \cdots + D_n}{N}$$

A : Average data

D_x : Data measured by n-th averaging

N : Average count

o EXP

Exponential averages are calculated. Every time new data is taken in, that and average data are temporally weighted for averaging. That is, the past average data and new data are added up while being evenly weighted as many times as the NUMBER setting. The formula is:

$$A\,(COUNT) = \frac{N-1}{N}\,A\,(COUNT-1) + \frac{1}{N}\,D$$

A ( ) : Average data

COUNT : Average count

N : NUMBER

D : Data measured at current averaging count

The previously averaged data is multipled by (NUMBER - 1)/ NUMBER. To this is added new data multipled by 1/NUMBER. The sum becomes new average data. The process is repeated as many time as specified. Here, NUMBER represents the weighting factor. The averaging count is set for 8192.
This is, averaging is carried out 8192 times.

- PEAK
  The peak hold operation is available. This is effective for magnitude spectra only. The peak value of a magnitude spectrum at each frequency setting is stored.

(2) Relationship between DOMAIN and MODE
Of the domain-and-mode combinations listed below, those marked by a cross (x) mean that the corresponding operation cannot be performed.

Table 7.1

DOMAIN \ MODE	SUMN	EXP	PEAK
TIME	o	o	x
HIST	o	o	x
SPEC	o	o	o

Note: Items can be changed when averaging is suspended. After changing an item, restart the execution.

7.3.2.2 TRIG Menu

The TRIG menu allows the trigger condition and related set-points to be specified. Triggering is controlled by the keys in the TRIG section.

AVRG
TRIG
SCAL
FUNC
COMP
WIND
OPTN
SENS
FREQ

LEVEL
+2/8

POSIT.
→PRE11

SLOPE
↑

SOURCE
INT

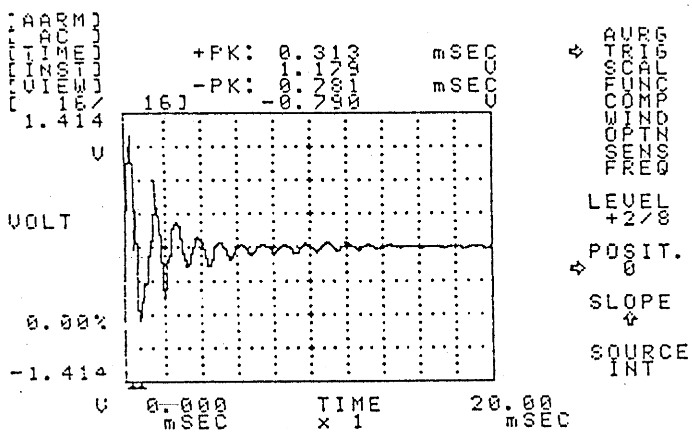
(a) LEVEL

Specify the trigger level in LEVEL. The setpoint may be between -7/8 and +7/8 in increments of 1/8 for the full scale of each input range.

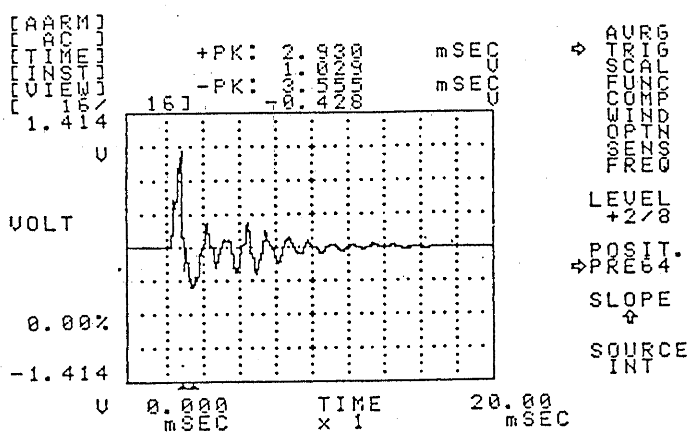
(b) POSIT.

POSIT. allows you to specify whether data is to be sampled before or after the reference point where the trigger is activated.

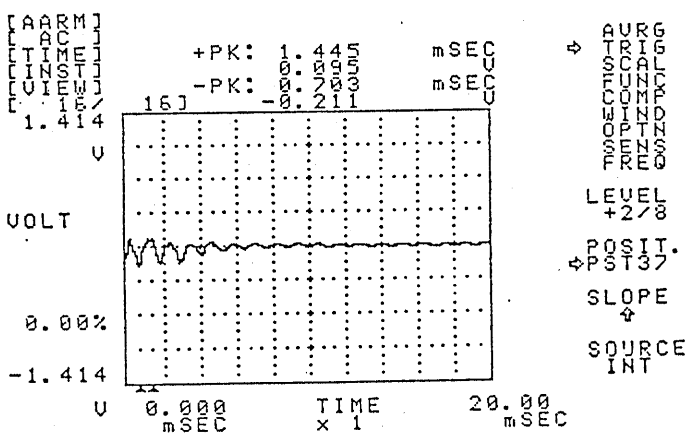
POSIT. "0" (zero) causes points-of-time data to be sampled 512 times after the trigger is activated.



POSIT. 0



POSIT. RRE 64



POSIT. PST 37

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PREnnn (up to 512) causes points-of-time data to be sampled 512 times nnn points prior to the point of time when the trigger is activated (pre-trigger).
PSTnnn (up to 512) causes points-of-time data to be sampled 512 times nnn points after the point of time when the trigger is activated (post-trigger).
This feature is useful for accommodating a single-shot phenomenon in a 512-point frame or for observing waveforms.

(c) SLOPE

SLOPE allows you to specify whether the trigger is to be activated at a leading edge or a trailing edge of an input signal waveform at the trigger level (internal trigger). Where an external trigger signal is used, select either a leading or a trailing edge for the external trigger clock.

- ↑ : The trigger is activated at a leading edge of the input signal waveform (internal trigger) or at a leading edge of the external trigger signal (external trigger).
- ↓ : The trigger is activated at a trailing edge of the input signal waveform (internal trigger) or at a trailing edge of the external trigger signal (external trigger).

(d) SOURCE

Specify using either the internal trigger (input signal) or an external trigger as the trigger source.

- INT : Internal trigger (input signal)
- EXT : External trigger (see the connector pin arrangement in 3). POSIT. and SLOPE are effective for EXT as well.

7.3.2.3 SCAL Menu

The SCAL menu allows units on the horizontal and vertical axes to be specified.

```
   AVRG
   TRIG
→  SCAL
   FUNC
   COMP
   WIND
   OPTN
   SENS
   FREQ

   F.UNIT
→  Hz
   Vrms/V
   V
   SCALE
   OFF
   OdBEU=

   dBU
   TIME
   × 1
   SPECT
   V²
```

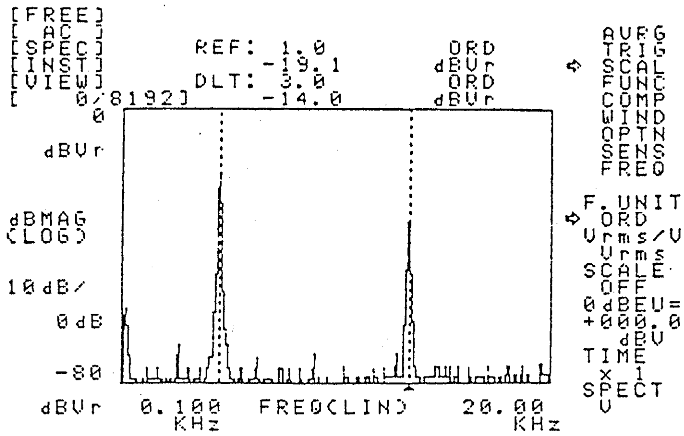
(a) F.UNIT

F.UNIT allows units for the readout of spectrum data on the horizontal axis to be selected for Hz, ORD and CPM.

Hz : Ordinary unit of frequency

ORD : A given frequency may be set for 1ORD (1st order) for readout. The Hz scale remains on the horizontal axis.

- With no cursor displayed
  A peak value is set for 1ORD for readout.
- With cursor displayed
  A peak value is set for 1ORD, with the cursor-set value read out.
- With delta (Δ) cursor displayed
  The reference cursor is set for 1ORD, with the cursor-set value read out.



o CPM : The CPM (cycle per minute) scale is set on the horizontal axis.

(b) Vrms/V

Select either Vrms (root mean square value) or V (amplitude value) for displaying magnitude spectrum data. When a value (V) is entered, it is multiplied by $\sqrt{2}$ and the product is displayed as a DC component.

(c) SCALE

SCALE allows you to specify how to read out magnitude spectrum data on the vertical axis: In EU (engineering unit; after conversion), or in /Hz (after operation).

- OFF : Both EU and /Hz scales are turned off. Values may be input in EU.
- SCL : The vertical axis is scaled using the input EU value. Scaling is done in 1 EU and 0 dB EU, respectively, for linear and algorithmic display of input data on the vertical axis.
- /Hz : Individual magnitude spectrum values are converted to energy per hertz. (These values are significant only with a continuous spectrum.) EU values may be input.

SL/Hz : A magnitude spectrum scaled in EU is converted to energy per hertz.

* See 8.4, "Inputting the Engineering Unit (EU)" for how to input the EU.

(d) TIME

TIME allows the scale on the horizontal axis to be selected for displaying time waveform data.

- 1x: 512-point display
- 2x: 400-point display
- 4x: 200-point display
- 8x: 100-point display
- 16x: 50-point display
- 32x: 25-point display

the selected scale is displayed at the bottom of the time waveform data display screen. Except for the 1x setup, the time frame may be shifted to view a desired portion of the input time data. (See explanation of the CURSOR & FRAME section.)

(e) SPECT

SPECT is effective only with the linear display of magnitude spectrum data on the vertical axis. Specify whether the value set in Vrms/V is to be displayed unchanged or squared. The relationship between Vrms/V and SPECT is as follows:

(v: RMS)

SPECT \ Vrms/V	Vrms	V(amplitude)
V	Effective value (v)	Magnitude ($\sqrt{2}$ v)
V^2	Power (v^2)	Power x 2 ($2v^2$)

Note: If the unit is nn mVr^2 with V^2, the resulting value is nn x $10^{-3}Vr^2$.

7.3.2.4 FUNC Menu

The FUNC menu allows addition and subtraction, differentiation and integration or overall operation to be selected and performed.

```
   AVRG
   TRIG
   SCAL
⇨  FUNC
   COMP
   WIND
   OPTN
   SENS
   FREQ

  FUNC.
⇨  OFF

  D.,I.
   OFF

  OV.ALL
   OFF
```

(a) FUNC.

FUNC. allows addition (+) and subtraction (-) to be selected and performed.

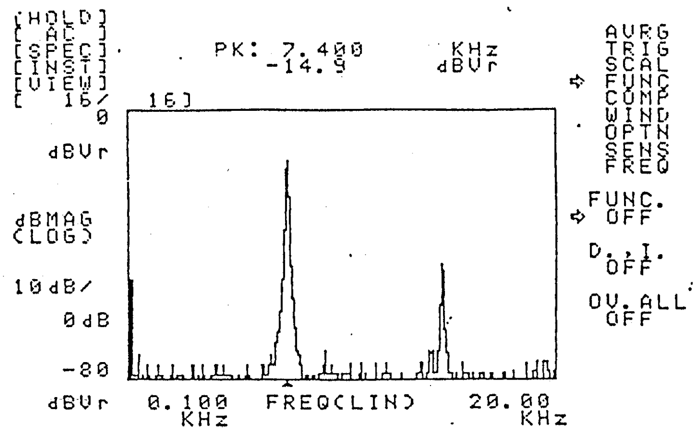
The data in waveform memory (see explanation of the MEMORY section) is added to, or subtracted from, the measured data displayed on the CRT. Selecting "OFF" disables addition and subtraction. In operation,

+ (measured data) + (memory data), or
- (measured data) - (memory data).

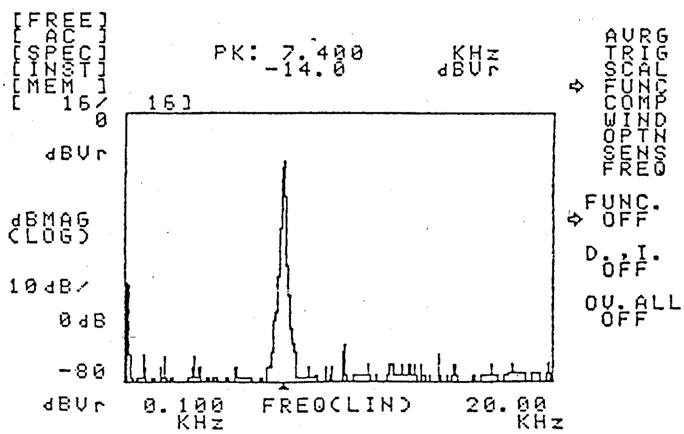
No operation is carried out if no data is in memory, or if the domain of measured data does not match that of memory data. When an operation is permitted, a plus (+) sign appears for addition and a minus (-) sign for subtraction in the leftmost column of the screen. With the operation permitted, the displayed contents may be changed with the keys in the VIEW section. Again, no operation is performed if the domain of the selected display fails to match that of memory data.

The sense range or frequency range cannot be changed during addition or subtraction. Nor is it possible here to carry out differentiation or integration. Addition or subtraction on the spectrum range is effective only when a magnitude spectrum is being displayed. The operation is performed on power spectrum data. For other displays the power spectrum data is processed, then converted to dB or magnitude values.

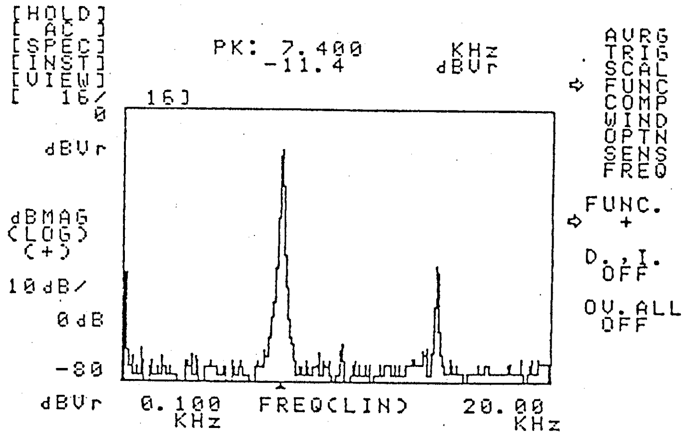
If the result from an operation on the spectrum range is negative, the result is set to zero.



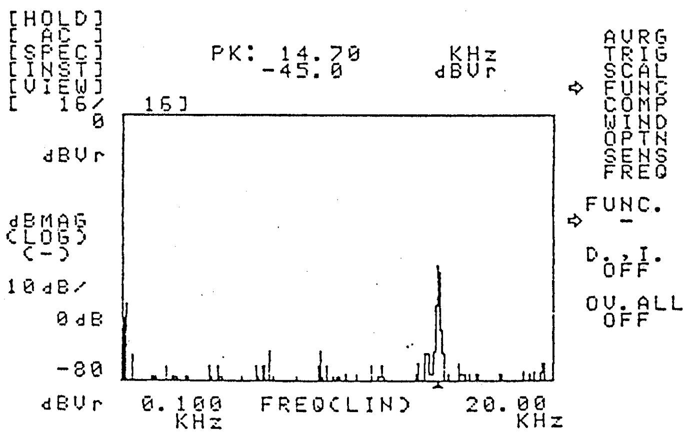
Measured data



Memory data



Measured data is added to memory data



Memory data is subtracted from measured data

(b) D., I.

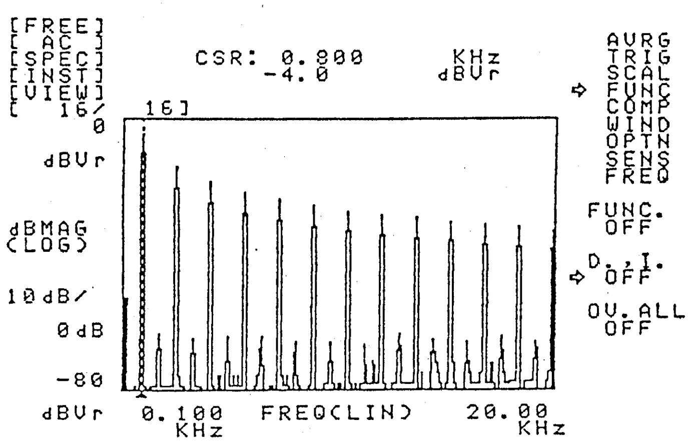
D., I. is an item that allows differentiation and integration to be carried out.

OFF	:	Differentiation and integration are suppressed.
jω	:	First differentiation is performed.
$-\omega^2$	:	Second differentiation is performed.
1/jω	:	Single integration is performed.
$1/-\omega^2$	:	Double integration is performed.

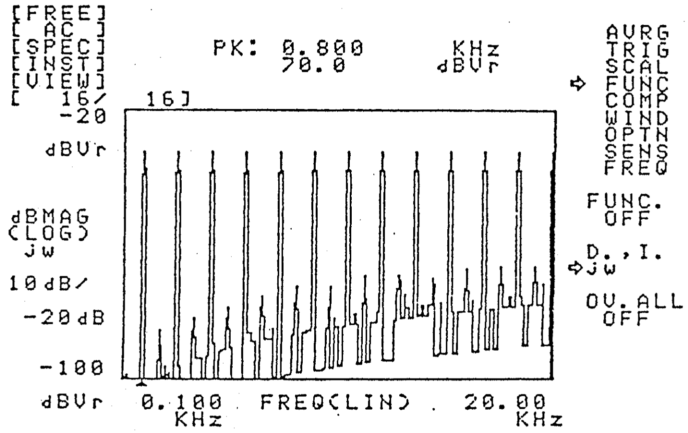
Differentiation and integration are effective only when a magnitude spectrum is displayed. When any other waveform

is displayed on the CRT, key-ins are accepted but neither differentiation nor integraion is carried out. When a key input is accepted, message "$j\omega$," "$-\omega^2$," "$1/j\omega$," or "$1/-\omega^2$" appears in the leftmost column of the screen.
In the frequency range, differentiation or integration of a time function is approximated by multiplying by $j\omega$, $-\omega^2$, $1/j\omega$ or $1/-\omega^2$. With the FAE2000, differentiation or integration of a time function is performed by multiplying by $j\omega$, $-\omega^2$, $1/j\omega$ or $1/-\omega^2$.
When differentiation or integration is performed, the magnitude spectrum data does not match the scale on the vertical axis. However, the peak value (peak position with differentiation or integration disabled), cursor-set value, and the value pointed to by the delta (Δ) cursor are internally computed with accuracy.
Sensors are calibrated using the EU function.

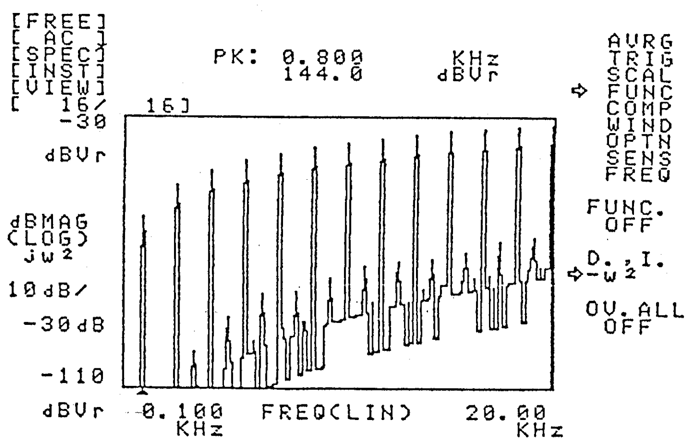
Note: The values of O.A, THD and THP are not obtained using a magnitude spectrum on which a differentiation or integration has been carried out. While addition or subtraction is in effect, differentiation and integration are suppressed.



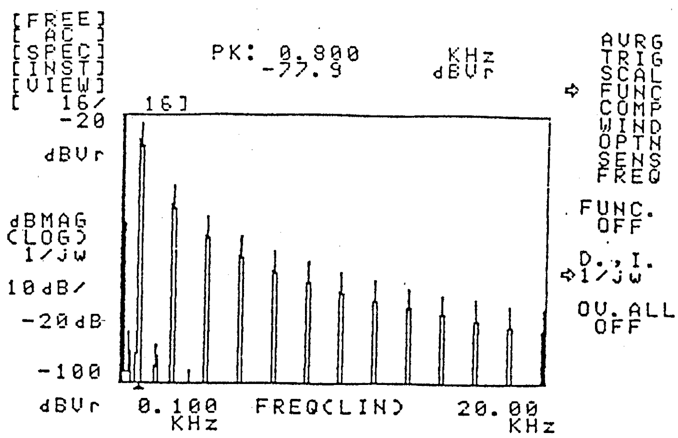
Differentiation and integration disabled



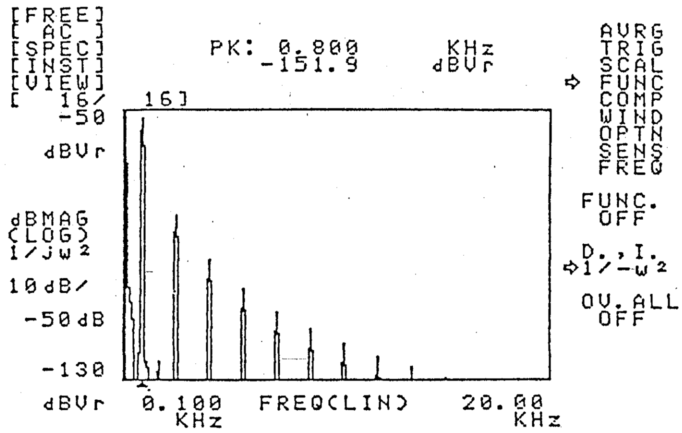
1st order differentiation



2nd order differentiation



Single integral



Double integral

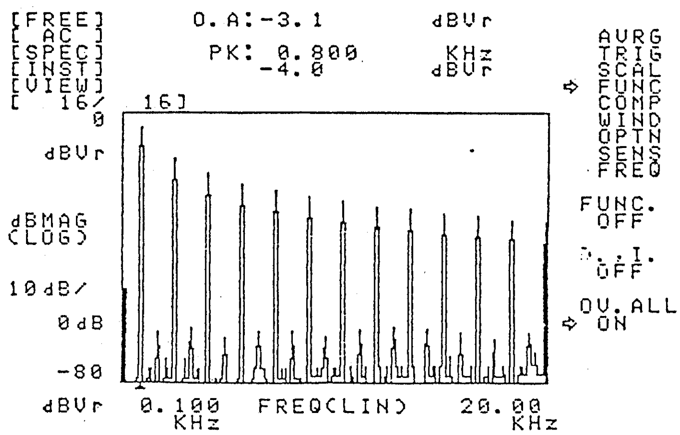
(c) OV.ALL

OV.ALL allows an overall or partial overall operation to be selected and performed. This item is effective only during a spectrum display.

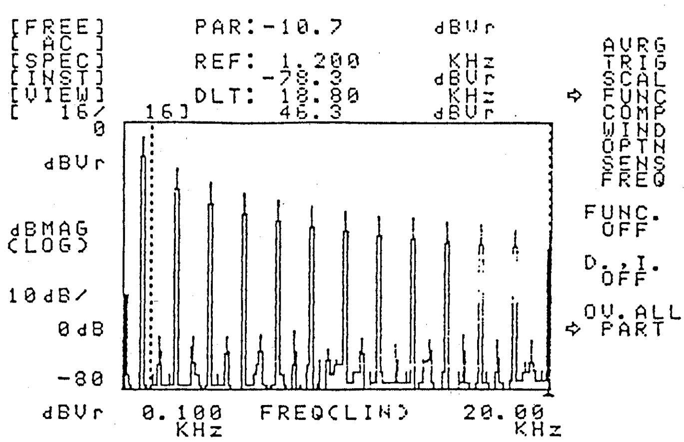
- OFF : Overall operation is suppressed.
- ON : Overall operation is performed, and the result is shown in the upper part of the CRT screen.
- PART: Partial overall operation is performed, and the result is shown in the upper part of the CRT screen. This operation is effective only when two cursors are being displayed (see explanation of the CURSOR & FRAME section). Without both cursors, PART cannot be selected.

The overall operation, when performed, provides the sum of the magnitude spectrum being displayed. The partial overall operation, when carried out, gives the sum of the powers of the magnitude spectrum being displayed between the two cursors. The results of overall and partial overall operations are compensated to appear accurately in any window selected.

Note: When addition or subtraction is being selected, the values of overall or partial overall operations are the result obtained using the magnitude spectrum that has undergone addition or subtraction. On the other hand, when differentiation or integration is being selected, the values of overall or partial overall operations are the result prior to the differentiation or integration. The values of overall or partial overall operations on /Hz or SL/Hz of the SCALE in the SCAL menu are meaningless.



Display of overall value from internally tested waveform



Display of partial overall value of harmonic element in internally tested waveform

7.3.2.5 COMP Menu

The COMP menu allows the compare condition and compare area to be specified.

```
   AVRG
   TRIG
   SCAL
   FUNC
→  COMP
   WIND
   OPTN
   SENS
   FREQ

   MARKER
→  OFF

   MODE
   FREE

   AREA
```

(a) MARKER

MARKER allows you to specify whether the comparator area set in the comparator area setting mode is to be displayed on the CRT or not.

OFF: The comparator area is not displayed.

ON : The comparator area set in the comparator area setting mode is displayed.

The performance of the comparator is not affected by whether the MARKER item is set to ON or OFF.

(b) MODE

MODE allows you to specify whether the compare operation is to be performed continuously or on a single-shot basis.

- FREE: The comparator runs continuously. When the START key in the COMP section is pressed in the comparator execution mode, the comparator starts running. It keeps running until the ON/OFF key in the COMP section is pressed to make the comparator exit comparator execution mode.

- SNGL: The comparator runs on a single-shot basis. That is, a compare operation is carried out every time the START key in the COMP section is pressed in the compare execution mode.

(c) AREA

Enter the comparator area setting mode. For how to set the comparator area, see 8.5, "Setting and Operating the Comparator."

7.3.2.6 WIND Menu

The WIND menu permits the anti-aliasing filter to be turned on and off, the buzzer to be turned on and off, a window to be selected, the total harmonic power (THP) or total harmonic distortion (THD) to be selected with harmonics on, and slow mode or fast mode to be selected.

```
   AVRG
   TRIG
   SCAL
   FUNC
   COMP
→  WIND
   OPTN
   SENS
   FREQ

  FILTER
→  ON

  BUZZER
   ON

  WINDOW
   HANN

  HARM.
   THD

  MODE
   SLOW
```

(a) FILTER

Specify in FILTER whether or not to use the anti-aliasing filter for the input signal.

- OFF: The anti-aliasing filter is not used.
- ON : The anti-aliasing filter is used.

The anti-aliasing filter keyed to the frequency range for analysis is selected automatically.

(b) BUZZER

Specify in BUZZER whether or not to activate the buzzer when a key is pressed.

- OFF: The buzzer remains inactive when a key is pressed. The buzzer sounds in case of overload.
- ON : The buzzer sounds when a key is pressed. A short "beep" sound is emitted if the key-in is accepted, and a long "beep" if the key-in is rejected.

(c) WINDOW

WINDOW selects a desired window.

- RECT: Selects rectangular window.
- HANN: Selects hanning window.
- FTOP: Selects flattop window.

For more information about windows, see 17, "BASICS OF FFT ANALYZER."

Note: The WINDOW setting cannot be changed when averaging is under way or when memory data is being displayed.

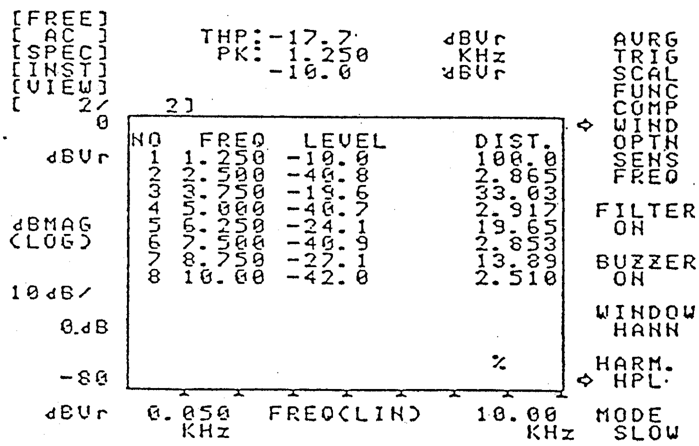
(d) HARM

Specify in HARM whether to obtain the total harmonic power (THP) or total harmonic distortion (THD) when the HARM key in the CURSOR & FRAME section is pressed. The THP or THD is effective only when a magnitude spectrum is displayed. The readout appears in the upper part of the screen.

When the system is equipped with an optional memory extension, you can get the following displayed in a list: THP or THD; the number of orders of fundamental and harmonic waves; frequencies; levels; and the ratio of the effective value of a harmonic wave to the effective value of the fundamental wave.

To display THP and the list at the same time, specify HPL. To display THD and the list at the same time, specify HDL. A typical display example is shown below.

For more information about THP and THD, see 17.7, "THP and THD."



(e) MODE

Select either SLOW mode or FAST mode in the MODE item.

SLOW: Processing is performed at normal speed.

FAST: With the readout of cursor-set values and other set points omitted, the FFT analyzer performs processing faster.

7.3.2.7 OPTN Menu

The OPTN menu is effective where the GP-IB interface, a printer, or expansion memory is installed.
See the instruction manual of the optional device attached for information.

7.3.2.8 SENS Menu

The SENS menu allows the input sensitivity (sense range) to be selected.

```
   AVRG
   TRIG
   SCAL
   FUNC
   COMP
   WIND
   OPTN
→  SENS
   FREQ

  RANGE
→   0dBV

 ±1.41 V
```

Any of 10 sense ranges may be selected between +30 dBV (±44.7 Vpeak) and -60 dBV (±1.41 mVpeak), with 1 Vrms set to 0 dBV.

Range	Effective value	Peak value	Sensi-tivity	Input con-nection
30 dB	31.6 Vrms	44.7 V	-30 dB	AC/DC
20 dB	10.0	14.1	-40	AC/DC
10 dB	3.16	4.47	-50	AC/DC
0 dB	1.00	1.41	-60	AC/DC
-10 dB	316 mVrms	447 mV	-70	AC/DC
-20 dB	100	141	-80	AC/DC
-30 dB	31.6	44.7	-90	AC/DC
-40 dB	10.0	14.1	-100	AC
-50 dB	3.16	4.47	-110	AC
-60 dB	1.00	1.41	-115	AC

Note: The sense range cannot be changed when; averaging is under way or suspended; when differentiation integration, addition, or subtraction is being performed; when measurement is on hold; or when memory data is being displayed.

7.3.2.9 FREQ Menu

The FREQ menu allows you to select a frequency range and to specify whether data is to be sampled using the internal clock or an external clock.

```
   AVRG
   TRIG
   SCAL
   FUNC
   COMP
   WIND
   OPTN
   SENS
→  FREQ

   RANGE
→  20KHz

   CLOCK
   INT

   FRAME
   10 mS
```

(a) RANGE

Select the frequency range for analysis in the RANGE item.

Frequency range	Frame time	Anti-aliasing filter
20 kHz	10 ms	20 kHz
10	20	10
5	40	5
2	100	2
1	200	1
500 Hz	400	500 Hz
200	1 s	200
100	2	100
50	4	50
20	10	20
10	20	10
5	40	10
2	100	10
1	200	10

When the frequency range for analysis is set, the anti-aliasing filter keyed to the range is automatically selected (provided FILTER is set to ON in the WIND menu).

Note: The frequency range for analysis cannot be changed when: Averaging is under way or suspended; when differentiation, integration, addition, or subtraction is being performed; when measurement is on hold; or when memory data is being displayed.

(b) CLOCK

Specify in CLOCK whether the internal sampling clock is to be set automatically with respect to the selected frequency range, or whether an external sampling clock is to be provided via the rear panel.

INT: The internal clock is used.
EXT: An external clock is used.

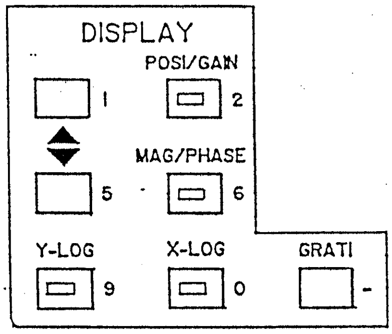
When EXT is specified and the external sampling clock is set for f kHz (51.2 kHz max.), the frequency range for analysis is set for f/2.56 kHz. For time display, the horizontal axis indicates an external clock count (0 - 511). For spectrum display, the horizontal axis indicates, 0 through 200. If the frequency is changed in the RANGE item, the anti-aliasing filter keyed to the Frequency range is automatically selected (provided FILTER is set to ON in the WIND menu). See 3, "SPECIFICATIONS OF FAE2000" for how to input external sampling clock pulses.

(c) FRAME

FRAME indicates the total sampling time (single-frame time) of up to 512 points in each frequency range for analysis. The contents of the FRAME item vary with those of the RANGE item. FRAME is just an indication of a single-frame time; it cannot be set arbitrarily.

7.3.3 DISPLAY Section

The keys in the DISPLAY section are used to manipulate the waveform data on the CRT screen into the desired shape.



POSI/GAIN key : This key specifies either magnifying or contracting of the displayed waveform, or moving it vertically. The LED means the following:

LED off: GAIN (magnification/contraction)
LED on : POSI (vertical movement)

▲▼keys : 1) When the POSI/GAIN key is set to GAIN, one of the following capabilities may be selected:

- Time waveform: 1x, 2x, 4x, 8x, 16x
- Histogram: 1x, 2x, 4x, 8x, 16x
- Linear spectrum of magnitude on vertical axis: Variable from 1x to 65536x multiples of 2
- Logarithmic spectrum of magnitude on vertical axis: Dynamic range for display; 80 dB, 70 dB, 60 dB, 50 dB, 40 dB, 35 dB, 30 dB, 25 dB, 16 dB
- Phase spectrum: 1x, 2x, 4x, 8x

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2) When the POSI/GAIN key is set to POSI:
   - Pressing the ▲ key moves the displayed waveform up.
   - Pressing the ▼ key moves the displayed waveform down.

Note 1: A time waveform or a phase spectrum waveform, when on display, is magnified or contracted around the center of the vertical axis on the screen.

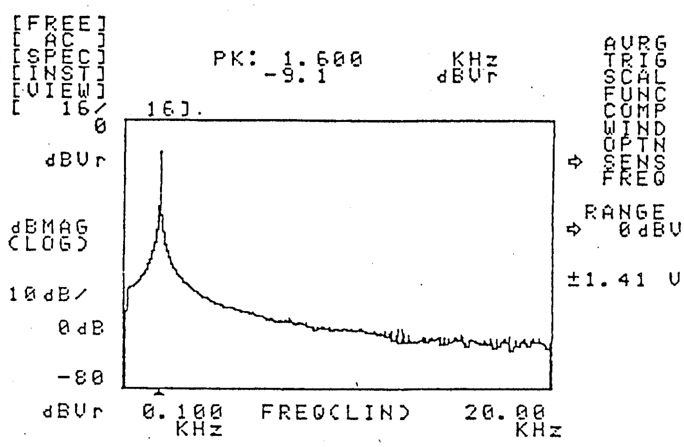
Note 2: When a linear spectrum of magnitude is displayed on the vertical axis, the form is magnified or contracted with respect to the X axis on the screen.

Note 3: When a logarithmic spectrum of magnitude is displayed on the vertical axis, the form is magnified or contracted with respect to the upper scale value on the screen.

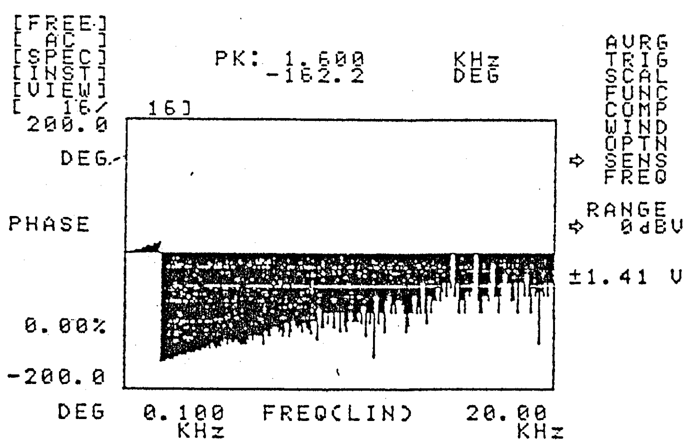
Note 4: The scale factor and offset that were set by the POSI/GAIN key are retained for each waveform screen. That is, if a previous waveform screen is called up to replace the current screen, the previously set scale factor and offset remain effective. The scale factor and offset are cleared by pressing that domain key in the VIEW section which corresponds to the screen.

MAG/PHASE key : This key is effective when a spectrum is displayed on the screen. The LED means the following:

LED off: Phase spectrum
LED on : Magnitude spectrum



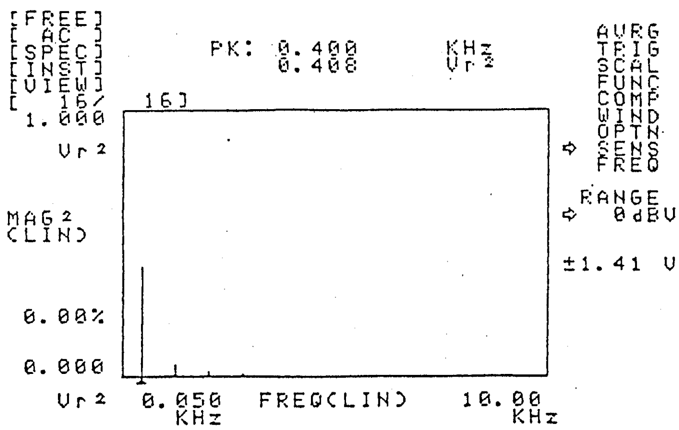
Magnitude spectrum



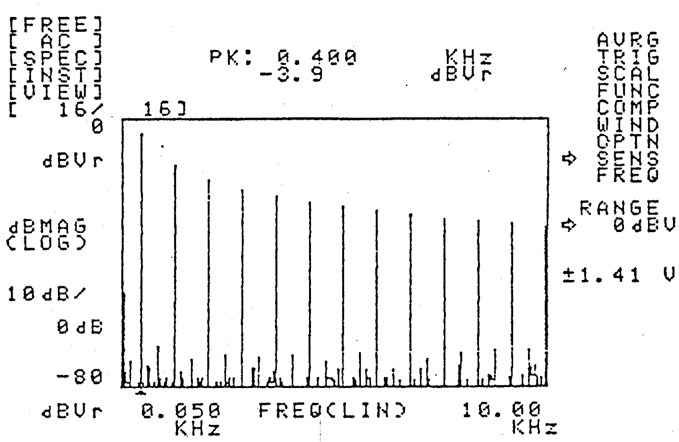
Phase spectrum

Y-LOG key : This key is effective when a magnitude spectrum is displayed on the screen. The LED means the following:

LED off: Linear vertical axis
LED on : Logarithmic vertical axis



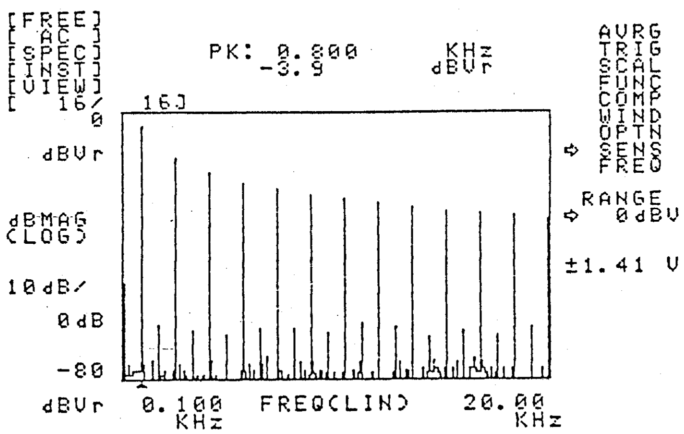
Linear spectrum of magnitude
on vertical axis



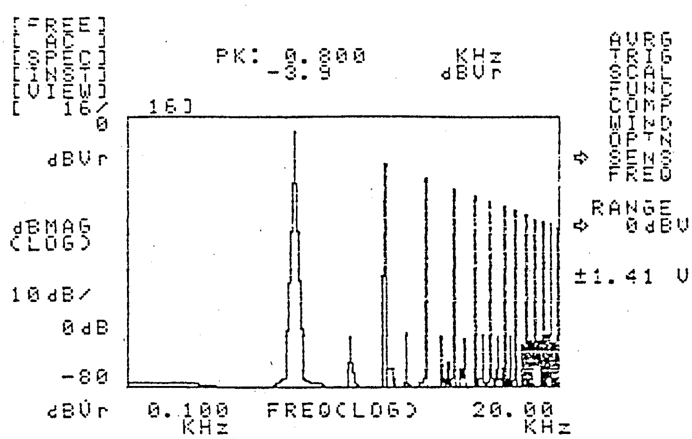
Logarithmic spectrum of magnitude
on vertical axis

X-LOG key : This key is effective when a magnitude spectrum is displayed on the screen. The LED means the following:

LED off: Linear horizontal axis
LED on : Logarithmic horizontal axis

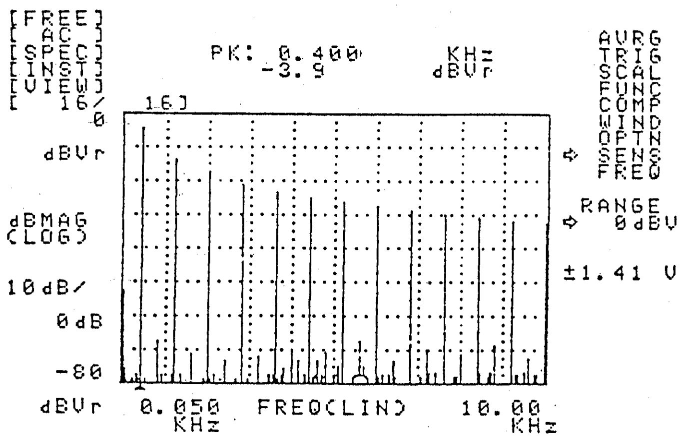


Linear spectrum of magnitude
on horizontal axis



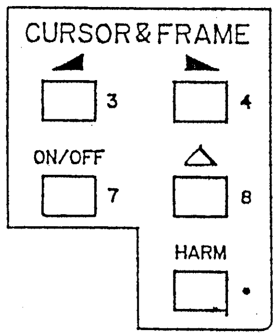
Logarithmic spectrum of magnitude
on horizontal axis

GRATI key : This key specifies whether or not to display a scale on the screen.



7.3.4 CURSOR & FRAME Section

The keys in the CURSOR & FRAME section are used to move the cursor(s), turn the harmonic cursors on and off, turn THD and THP on and off, and move the frame in which to display the time waveform.



ON/OFF key : This key specifies whether or not to display the cursor(s) on the screen.

- With LED off

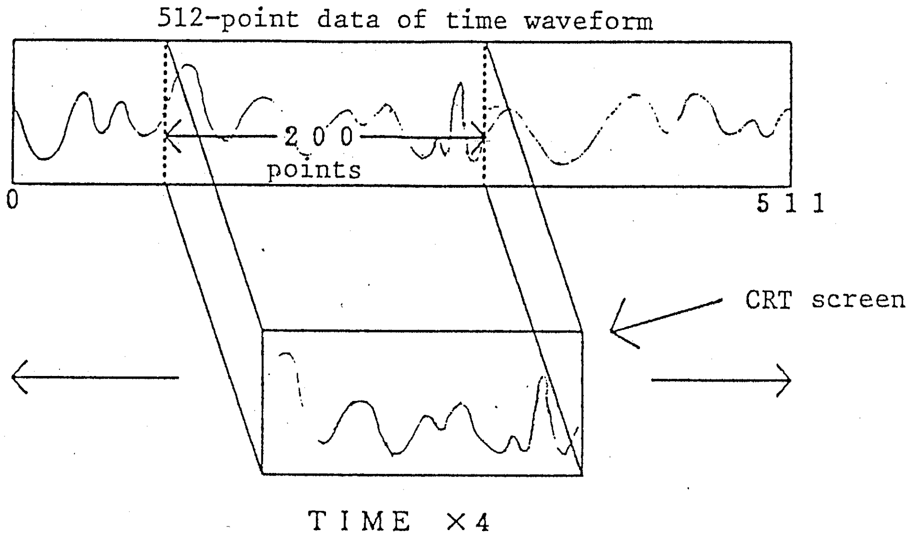
  The cursor is not displayed. The readout indicates the waveform value in a peak position, pointed to by a "▲" in the lower part of the waveform display screen. On a time waveform display, the maximum and minimum values are searched for within the displayed time range. Their position and the corresponding voltages are indicated.

Where the scale factor is other than 1x (512-point dispaly) for time waveform display, the frame can be moved with the (◄ ►) keys (frame mode).

- With LED on
  The cursor is displayed, and is moved with the (◄ ►) keys. The readout of the cursor value is shown in the upper part of the screen (cursor mode).

◄ ► keys :

- With LED of the ON/OFF key turned off:
  Where the scale factor is other than 1x (512-point display) for the time waveform display, the frame can be moved with the (◄ ►) keys (frame mode).



The CRT screen (i.e., frame) can be moved crosswise with the (◄ ►) keys.
The display begins with the top of the whole time waveform by changing the scale factor in the TIME item of the SCAL menu.
The (◄ ►) keys are irrelevant if the scale factor is 1x (512-point display) for time waveform display, or if a histogram or spectrum is being displayed.

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- With LED of the ON/OFF key turned on (cursor mode):
  Pressing the ON/OFF key causes the cursor to appear on the waveform display screen. The cursor usually appears in the position where it last appeared. The cursor is moved to the leftmost column when a change is made in the TIME item of the SCAL menu or in the display domain.
  The cursor can be moved crosswise with the (◄ ►) keys. The readout indicates the waveform value in each cursor position.

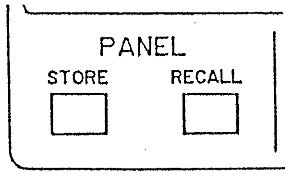
Delta (Δ) cursor : The delta (Δ) cursor is effective in the cursor mode alone. The delta (Δ) key is used to obtain the difference between two points. With the cursor on the CRT screen, pressing the delta (Δ) key (LED on) turns on the reference cursor at the current cursor position. The current cursor can be moved by with the (◄ ►) keys.
The cursor without the "▲" mark under it is the reference cursor. The difference between two cursors are calculated for readout display.

HARM Key : This key, effective when a magnitude spectrum is displayed, is used to turn the harmonic cursors on and off. Pressing this key causes the cursors to appear on the waveform display screen. A total of 11 cursors (up to the 11th harmonic; fundamental wave cursor included) are displayed.
The fundamental wave is located at the peak when the ordinary cursor is turned off, and located at the maximum value within the position pointed to by the cursor ±3 lines when the cursor is on.

The value keyed to the HARM item of the WIND menu is displayed for readout in the upper part of the screen.

7.3.5 PANEL Section

The keys in the PANEL section are used to store the panel setting conditions (set by key) and recall the stored conditions later.

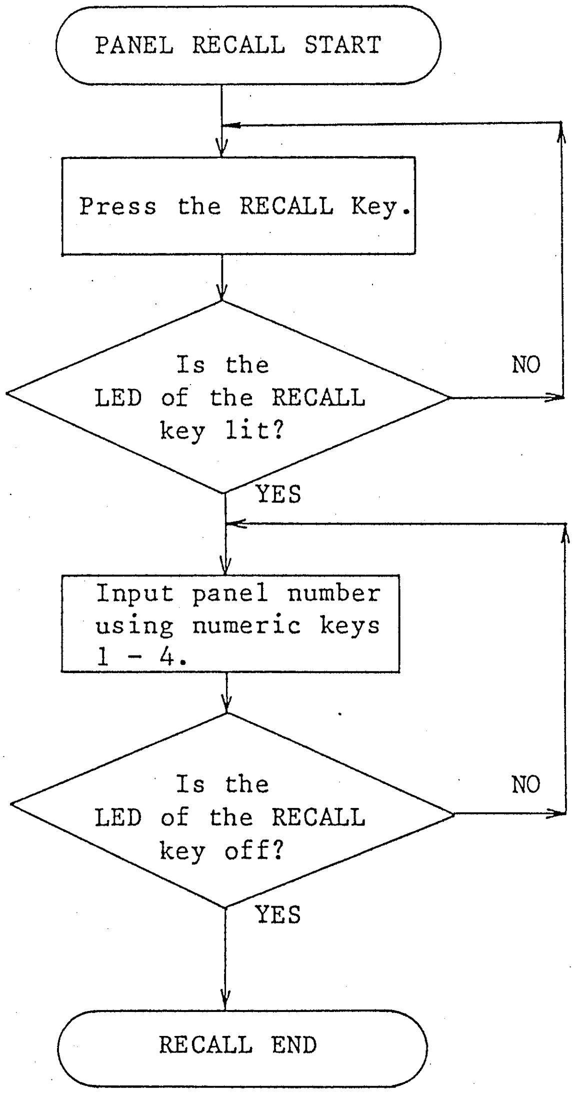


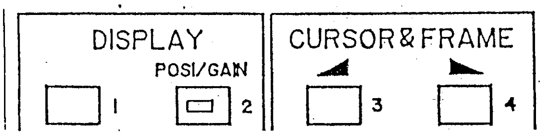
The standard setup allows up to four panel setting conditions, including the comparator area, to be stored. The conditions are stored and recalled, respectively. With the STORE and RECALL keys, plus numeric keys.
Where expansion memory is installed, more panel setting conditions are stored. For more information, refer to 11, "EXPANSION MEMORY."

Note 1: The state of averaging, i.e., the state of being under way, suspended or completed, is not stored. The number of times averaging is performed is not stored when averaging is under way, suspended or completed.

Note 2: Which of the menus is being displayed is not stored.

How to Recall Panel Setting Conditions



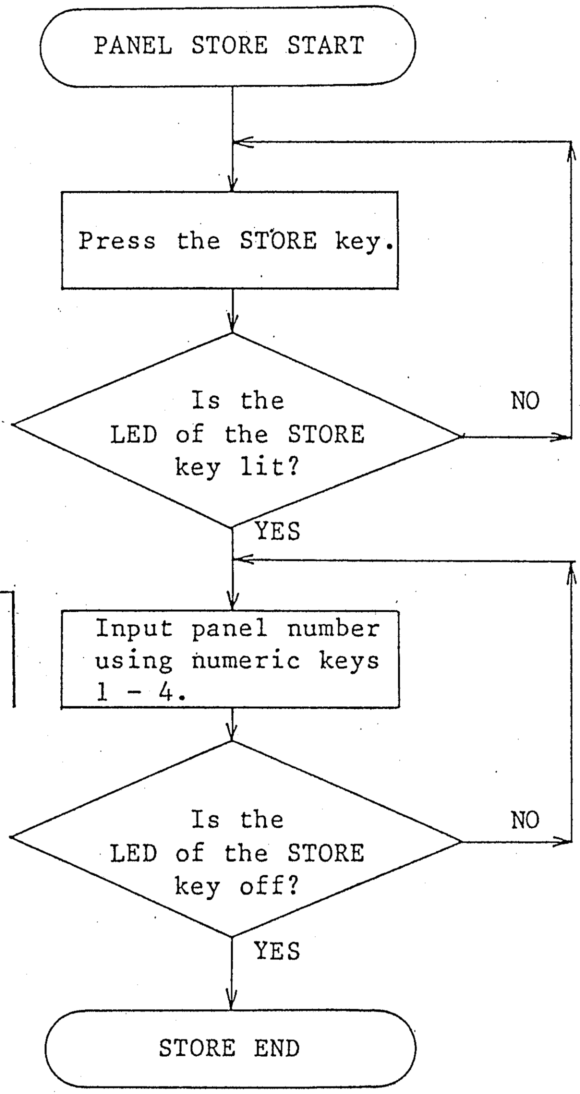


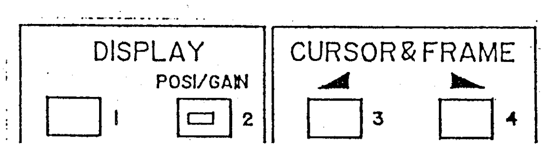
Numeric keys

* When the LED of the RECALL key is lit, only numeric keys 1 through 4 are operable.

* To suspend the panel recall operation, press the RECALL key or the STORE key. The LED of the RECALL key will then go out.

How to Store Panel Setting Conditions



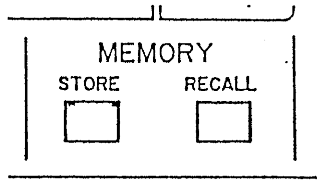


Numeric keys

* When the LED of the STORE key is lit, only numeric keys 1 through 4 are operable.
* To suspend the panel store operation, press the STORE key or the RECALL key. The LED of the STORE key will then go off.

7.3.6 MEMORY Section

The MEMORY section is used to store and recall measured data.



The standard setup allows one kind of measured data to be stored. The measured data is stored and recalled with the STORE and RECALL keys respectively. Where expansion memory is installed, more measured data can be stored. For more information, see 11, "EXPANSION MEMORY."

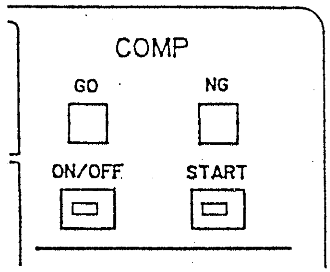
- How to store measured data
  Pressing the STORE key puts into memory the waveform displayed on the screen. Even if the scale factor is not 1x for the time waveform display (512-point display), all the 512 points of data are stored. The panel setting condition in effect when the STORE key is pressed is also stored.

- How to recall stored data
  Pressing the RECALL key causes the waveform to be moved from memory to the screen. If no waveform is stored in memory, the RECALL key is inoperable. When the waveform is recalled, the panel setting condition stored with it is also recalled. Indication [MEM] replaces [VIEW] on the screen. The recalled waveform can be subjected to manipulation such as scaling.

- How to restore the ordinary measurement screen
  Press TIME, SPECT or HIST key in the VIEW section, and the panel setting condition in effect before the waveform is recalled is restored. Indication [VIEW] replaces [MEM] in the upper part of the screen.

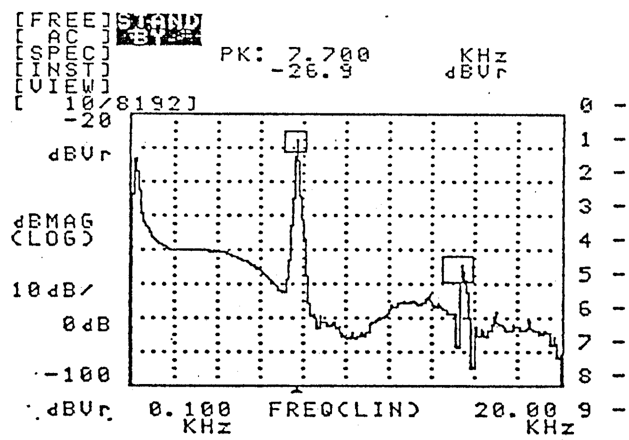
7.3.7 COMP Section

The COMP section controls the comparator function.



ON/OFF key : This key turns the comparator function on and off. The LED means the following:
LED off: The comparator cannot be executed.
LED on : The comparator can be executed.

When the key is turned on, the screen in which the comparator area is set appears. The area number is shown in the rightmost column (comparator execution mode). At this time, all the keys except for those in the COMP, TRIG, and PRINT sections are disabled. To exit comparator execution mode, or to suspend execution of the comparator while the comparator execution mode is on, press the ON/OFF key. The LED of the ON/OFF key will then go off, and the ordinary screen will be restored.



Comparator execution mode

START key : Pressing this key in the comparator execution mode starts the comparator. The LED means the following:

LED off: The comparator is not in execution.
LED on : The comparator is in execution.

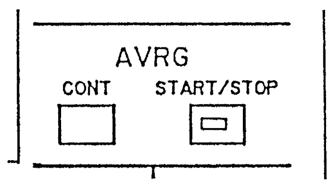
When execution of the comparator comes to an end, the compared result is indicated by a glowing "GO" or "NG" LED, a buzzer beep and relay output.

	LED	Buzzer beep	Relay
Good	GO ☐	Short	(See 3, "SPECIFICATIONS OF FAE2000".)
No good	NG ☐	Long	

(See 8.5, "Setting and Operating the Comparator.")

7.3.8 AVRG Section

The AVRG section is used to control averages.



If the averaging condition set in each item of the AVRG menu is appropriate, the specified averaging is carried out. If not, an error results and no averaging is performed. Notice that averaging is carried out even if the domain of the waveform being displayed does not match the domain for averaging.

With averaging carried out, the set averaging count and the current averaging count are displayed in the top left corner of the CRT screen. The set averaging count is the denominator, and the current averaging count is the numerator. If the input signal causes an overflow, the data at that time is not used for averaging. That is, averaging is suspended during the overflow, and the averaging count remains unchanged.

START/STOP key : This key is used to start or suspend averaging. The LED means the following:

LED off: Averaging has yet to be performed, is being suspended, or is terminated.

LED on : Averaging is being performed.

- When the LED is off, pressing the START/STOP key clears the current averaging count, starts averaging, and lights the LED.
- When the LED is on, pressing the START/STOP key suspends averaging and turns off the LED.

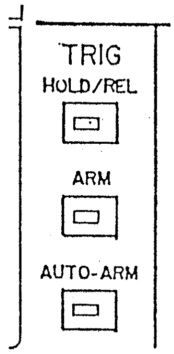
COUNT key : This key is operable when averaging is suspended. Pressing this key causes averaging to resume.

Note 1: During averaging, it is impossible to change the frequency range, sense range, and contents of any itme in the AVRG menu.

Note 2: When averaging is suspended, the frequency range, sense range, and contents of each item in the AVRG menu may be changed. After a change, restart averaging.

7.3.9 TRIG Section

The TRIG section is used to activate the trigger under the trigger conditions set in each item of the TRIG menu.



HOLD/REL key : This key is used either to hold (stop) accepting data, or to release the data input. The LED means the following:

LED off: REL (free-run)

LED on : HOLD (stop)

When the LED is off (free-run), an indication [FREE] appears in the top left corner of the screen. When the LED is on (stop), an indication [HOLD] appears in the same position.

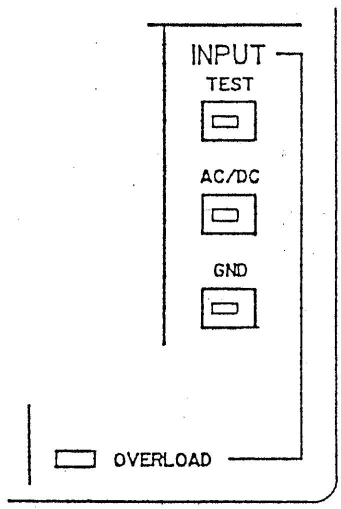
ARM key : This key is used to activate a single-shot trigger operation. Pressing this key lights the LED and makes the system ready for a trigger shot. When activated, the trigger occurs and accepts data of 512 points, followed immediately by a hold state; the LED of the ARM key goes off, and the HOLD/REL key has its LED lit up.

The trigger wait state is ended by pressing the ARM key (with its LED turned off). While the ARM function is in use, [ARM] appears in the top left corner of the screen.

AUTO-ARM key : This key activates continuous triggering. Pressing this key turns off its LED and executes continuous triggering. The continuous triggering state is left by pressing this key (with its LED turned off). While the AUTO-ARM function is in use, [AARM] appears in the top left corner of the screen.

7.3.10 INPUT Section

The INPUT section is used to select input signals.



TEST key : This key admits the internal test signal as the input signal. The internal test signal is a square wave (0 - 1.41 V) with a frequency of 4 percent of each frequency range. The LED means the following:

- LED off: An external signal is admitted as the input signal.
- LED on : The internal test signal is admitted as the input signal.

AC/DC key : This key selects an input coupling. The LED means the following:

- LED off: Direct coupling (DC) is selected.
- LED on : A low-pass filter (0.5 Hz, -3 dB) is turned on (AC).

GND key : This key connects the input internally to ground. The LED means the following:

LED off: The input is disconnected from the internal ground and connected to the input signal.

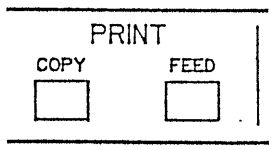
LED on : The input is connected internally to ground.

* The GND key is inoperable when the internal test signal is used. [AC] appears for the AC setup, [DC] for the DC setup, and [GND] for ground connection, in the top left corner of the screen.

OVERLOAD : This is an excess input indicator, lights up when the FAE2000 is overloaded. If this LED glows when the FAE2000 is not overloaded during time waveform observation, an excess input of a frequency higher than the measurement frequency range is suspected to be applied to the FAE2000.

7.3.11 PRINT Section

The PRINT section is operable when the printer unit is attached.



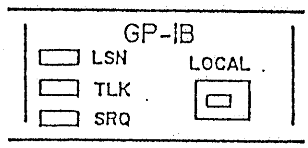
COPY key : Pressing this key prints out screen hard copy and parameter lists.

FEED key : This key feeds paper. Pressing this key during printing stops operation.

(See 9, "HOW TO USE THE PRINTER.")

7.3.12 GP-IB Section

The GP-IB section is used when the GP-IB board is installed. For more information about the GP-IB board, refer to 10, "GP-IB OPERATION."



In the local state, the LED of the LOCAL key is lit.

CHAPTER 8. OPERATION

This chapter explains how the FAE2000 is actually operated.

8.1 Measuring the Time Waveform

(1) Displaying the time waveform
Press the TIME key in the VIEW section.

(2) Changing the frequency range
Press the FREQ key in the SETUP section. Select the FREQ menu. Change the contents of the RANGE item.

(3) Changing the sense range
Press the SENSE key in the SETUP section. Select the SENS menu. Change the contents of the RANGE item.

(4) Setting the trigger level
Select the TRIG menu using the MENU (▲▼) keys in the SETUP section. Change the contents of the LEVEL item.

(5) Setting the post-trigger/pre-trigger
Select the TRIG menu using the MENU (▲▼) keys in the SETUP section. Set the POSIT item as desired.

PST: Post-trigger selected
PRE: Pre-trigger selected

(6) ∘ Selecting leading/trailing trigger (internal trigger: activated by input signal)

∘ Selecting leading/trailing edge (external trigger: activated by external trigger clock)

Select the TRIG menu using the MENU (▲▼) keys in the SETUP section. Select the SLOPE item.

↑ : Leading trigger/edge selected
↓ : Trailing trigger/edge selected

(7) Selecting the trigger signal source
Select the TRIG menu using the MENU (▲▼) keys in the SETUP section. Change the contents of the SOURCE item.

INT : Internal trigger (the input signal becomes the trigger source)
EXT : External trigger (an external trigger signal becomes the trigger source)

(8) Executing the single-shot trigger
Press the ARM key in the TRIG section, and the LED will light and the trigger signal wait state will be entered. When the trigger is activated, data sampling of 512 points is carried out. Then the hold state is entered.

(9) Executing the continuous trigger
Press the AUTO-ARM key in the TRIG section, and the LED will light and the trigger will be activated continuously.

(10) Setting and executing the time average
Select the AVRG menu using the MENU (▲▼) keys in the SETUP section. Change the contents of the NUMBER and MODE items as needed (but leave PEAK unchanged). Set

DOMAIN to TIME. Press the START/STOP key in the AVRG section.

(11) Displaying the time averaging waveform
When time averaging is carried out, suspended, or ended, set the AVG/INST key to AVG (LED on) in the VIEW section.

(12) Displaying a magnitude spectrum, phase spectrum or histogram for time averaging.
Carry out step (10) above. Press keys as follows.

- To display a magnitude spectrum, operate:
  SPECT MAG/PHASE (LED on) AVG/INST (LED on)
- To display a phase spectrum, operate:
  SPECT MAG/PHASE (LED off) AVG/INST (LED on)
- To display a histogram, operate:
  HIST AVG/INST (LED on)

(13) Magnifying/contracting the vertical axis
Set the POST/GAIN key to GAIN (LED off) in the DISPLAY section. Adjust the scale factor using the (▲▼) keys (1x, 2x, 4x, 8x, 16x).

(14) Moving the waveform up and down
Set the POSI/GAIN key to POSI (LED on) in the DISPLAY section. Move the waveform using the (▲▼) keys.

- To move the waveform upward, press the (▲) key
- To move the waveform downward, press the (▼) key

(15) Changing the scale on the horizontal axis
Select the SCAL menu using the MENU (▲▼) keys in the SETUP section. Change the contents of the TIME item (1x, 2x, 4x, 8x, 16x, 32x).

(16) Shifting the frame
Set the ON/OFF key to OFF (LED off) in the CURSOR & FRAME section.

- To move the frame leftward, press the (◄) key.
- To move the frame rightward, press the (►) key.
  (These operations are not available if the horizontal axis is on the 1x scale.)

(17) Displaying the cursor and reading a desired point
Set the ON/OFF key to ON (LED on) in the CURSOR & FRAME section.

- To move the cursor leftward, press the (◄) key.
- To move the cursor rightward, press the (►) key.

(18) Reading the difference of voltage/time between cursors
Carry out step (17). Press the (Δ) key in the CURSOR & FRAME section. Move the cursors with the (◄ ►) keys.

(19) Storing the time waveform
Get the time waveform displayed. Press the STORE key in the MEMORY section.

(20) Performing addition/subtraction (±)
Select the FUNC menu using the MENU (▲▼) keys in the SETUP section. Select the FUNC item. (This feature is not available if no time waveform is stored.)

8.2 Measuring the Spectrum

(1) Displaying the spectrum
Press the SPECT key in the VIEW section.

(2) Displaying the magnitude spectrum
Carry out step (1) above. Set the MAG/PHASE key to MAG (LED on) in the DISPLAY section.

(3) Displaying the phase spectrum
Carry out step (1) above. Set the MAG/PHASE key to PHASE (LED off) in the DISPLAY section.

(4) Selecting a logarithmic or linear vertical axis
Operate the Y-LOG key in the DISPLAY section to select either a logarithmic or a linear vertical axis.

LED on : Logarithmic vertical axis selected
LED off: Linear vertical axis selected

(5) Selecting a logarithmic or linear horizontal axis
Operate the X-LOG key in the DISPLAY section to select either a logarithmic or a linear horizontal axis.

LED on : Logarithmic horizontal axis selected
LED off: Linear horizontal axis selected

(6) Magnifying/contracting the vertical axis, and changing the dynamic range for logarithmic display
Set the POSI/GAIN key to GAIN (LED off) in the DISPLAY section. Press the (▲▼) keys.

(7) Moving the waveform up and down
See step (14) in 8.1.

(8) Changing the window
Select the WIND menu using the MENU (▲▼) keys in the SETUP section. Change the contents of the WINDOW item.

(9) Displaying THD and THP
Select the WIND menu using the MENU (▲▼) keys in the SETUP section. Press the HARM key in the CURSOR & FRAME section.

(10) Selecting the effective value, magnitude and power spectrum
Select the SCAL menu using the MENU (▲▼) keys in the SETUP section. Change the contents of the Vrms/V and SPECT items.

(11) Performing addition/subtraction (±)
See step (20) in 8.1.

(12) Differentiating/integrating
Select the FUNC menu using the MENU (▲▼) keys in the SETUP section. Change the contents of the D. and I. items.

(13) Displaying the cursor and reading a desired point
See step (17) in 8.1.

(14) Reading the difference in spectrum/frequency between cursors
See step (18) in 8.1.

(15) Overall/partial overall
Select the FUNC menu using the MENU (▲▼) keys in the SETUP section. Set the OV.ALL item to ON for overall, and to PART for partial overall.

(16) Setting and executing the magnitude spectrum average
Select the AVRG menu using the MENU (▲▼) keys in the SETUP section. Change the contents of the NUMBER and MODE items as needed. Set the DOMAIN item to SPEC. Press the START/STOP key in the AVRG section.

(17) Displaying the magnitude spectrum average waveform
When magnitude spectrum averaging is performed, suspended or terminated, set the AVG/INST key to AVG (LED on) in the VIEW section.

8.3 Measuring the Histogram

(1) Displaying the histogram
Press the HIST key in the VIEW section.

(2) Magnifying/contracting the histogram
See step (13) in 8.1.

(3) Setting and executing the histogram average
Select the AVRG menu with the MENU (▲▼) keys in the SETUP section. Change the contents of the NUMBER and MODE items as needed (but leave PEAK unchanged). Set the DOMAIN item to HIST. Strike the START/STOP key in the AVRG section.

(4) Displaying the histogram average waveform
Carry out step (3) above. Set the AVG/INST key to AVG (LED on) in the VIEW section.

(5) Performing addition/subtraction (±)
See step (20) in 8.1.

8.4 Inputting the Engineering Unit (EU)

Select the SCAL menu with the MENU (▲▼) keys in the SETUP section. Select the SCALE item with the NEXT key. Set the SCALE item to OFF or /Hz with the ITEM (▲▼) keys. Move the cursor (→) one line down with the NEXT key, which enters an EU value input setting state. In this state, only the COMPSET key, NEXT key, and numeric keys are operable.

The EU input format consists of a 3-digit integer part and a 1-digit fraction part for dB input. For linear input, the format is made up of a 3-digit fixed-point part (integer) and a 1-digit exponent part. All numerals are input with numeric keys.

As numeric keys are pressed, the corresponding numerals are displayed from left to right on the screen. If any numeric key is pressed or if an operator (+, -) is input in the EU value input setting state, all keys except the numeric keys are disabled until four numerals are input.

<u>For dB input</u>

(in case of +123.4 dBV is input)

A plus (+) sign is automatically displayed when '1' is input. ——→

```
OFF
OdBEU =
+123.4
     dBV
```

A decimal point (.) is automatically displayed when '4' is input.

(in case of -123.4 dBV is input)

Input a minus (-) sign before typing '1' ——→

```
OFF
OdBEU =
-123.4
     dBV
```

<u>For linear input</u>
(in case of 123E+4 is input)

A plus (+) sign is automatically displayed when '1' is input. ⟶

```
OFF
1EU   =
+123+4
    ↑V
```

A plus (+) sign is automatically displayed when '4' is input.

Input a minus (-) sign before typing '4'

```
OFF
1EU    =
+123-4
    ↑V
```

When four numerals have been input, all keys revert to their original functions. The value has now been set. If there is an input mistake, complete the numeral input anyway, enter the EU value input setting state again by pressing the NEXT or COMPSET key switch, and repeat the numeral input.
EU scaling is made possible regardless of the vertical axis being linear or logarithmic; linear input is internally converted to logarithmic data, and vice versa.
EU execution is available only with magnitude spectra. For execution, set the SCALE item to SCL or SL/Hz.

When the system is equipped with an optional memory extension, you can set either the peak value shown in the magnitude spectra or the level of the point indicated by the cursor as the EU value.

When setting the peak value as the EU value, display it in the readout field of the display. When setting the level of the point indicated by the cursor as the EU value, display the level value in the readout field of the display.

When the entry of EU values is enabled, press the ITEM key. The current readout value is thus set as the EU value.

8.5 Setting and Operating the Comparator

8.5.1 Comparator Specifications

The standard FAE2000 is equipped with a comparator function. Compare operations are available in any domain: time waveform, spectrum or histogram. (Notice that in the spectrum domain, compare operations are available only on magnitude spectrums.) On the screen, a desired area is enclosed by a rectangular frame (Fig. 8.1). This is a comparator area. Up to 10 comparator areas may be set up.

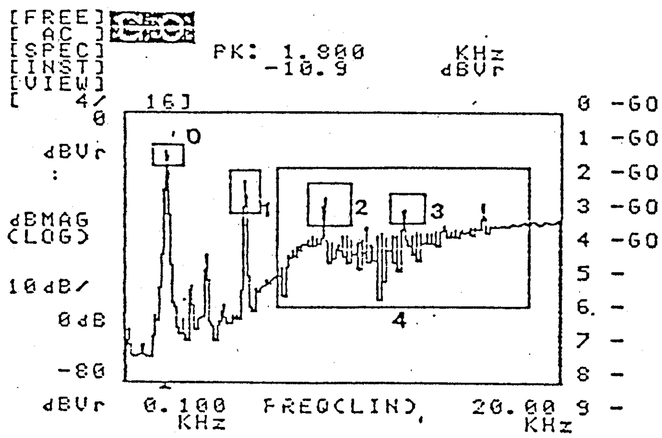


Fig. 8.1 Example of Comparator Area Display (no area number indicated on the waveform screen)

For each comparator area, specify a compare method: level comparator, peak comparator, or partial overall comparator (applicable in magnitude spectrum domain only). The output of the result is 'GO' only if all the comparator areas are 'GO'. The result is output as LED, screen and relay indications. For each comparator area set up, the result of the compare operation is displayed on the screen.

o Level comparator (LEVEL):
The level comparator shows 'GO' if a waveform exists between the upper and lower limits of the comparator area established, and 'NG' if waveform exceeds the upper and/or lower limits.

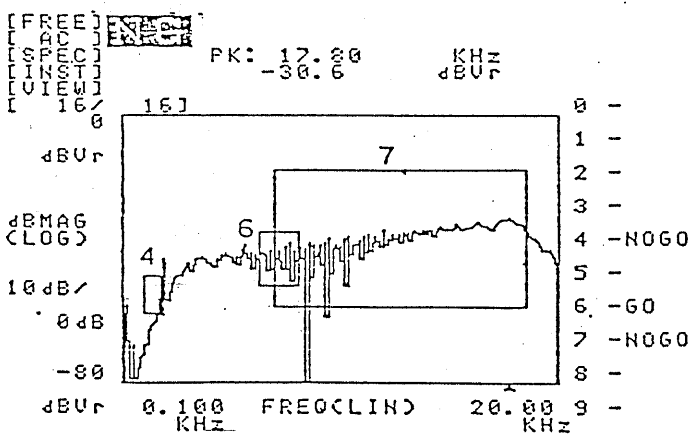


Fig. 8.2 Example of Level Comparator
(no area number indicated on the screen)

o Peak comparator (PEAK):
The peak comparator shows 'GO' if a positive (+) peak exists in the comparator area established, and 'NG' if no positive peak exists within the area.

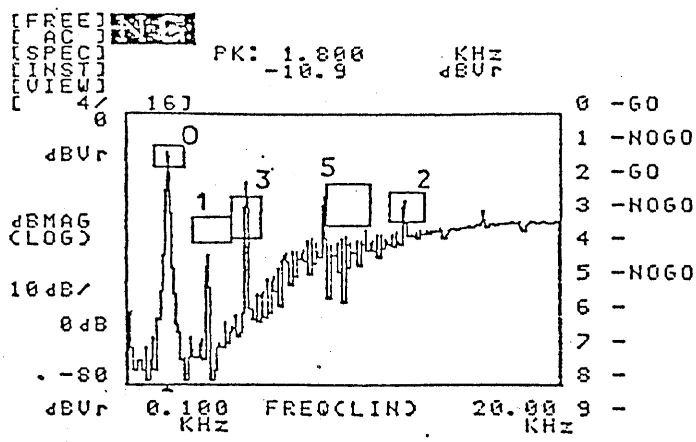


Fig. 8.3 Example of Peak Comparator
(no area number indicated on the screen)

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- Partial overall comparator (Poa):
  The partial overall comparator shows 'GO' if the partial overall value between the left- and right-hand limits of the comparator area established comes between the upper and lower limits of the area. 'NG' is indicated if the value exceeds these limits. This comparator is operable with magnitude spectra only.

  Lower limit ≦ Poa value between left- and right-hand limits ≦ upper limit GO

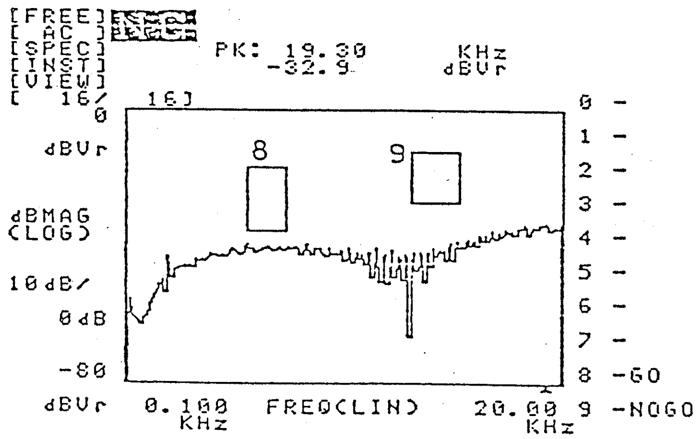

Fig. 8.4 Example of Partial Overall Comparator (no area number or other message displayed on the screen)

8.5.2 Setting the Comparator Area

To set up a comparator area requires entering a comparator area setting mode. When this mode is entered, the current setpoints (below) on the panel are stored as comparator executing conditions. That is, the panel should be set before the comparator area setting mode is entered.

1) Displayed waveform domain
2) Average or instant waveform, whichever is selected
3) Sense range
4) Frequency range

5) Logarithmic or linear vertical axis for magnitude spectrum display, whichever is selected (effective value, magnitude, power, or power x 2 for linear display, whichever is selected)
6) Internal or external clock, whichever is selected

Waveforms affected by offset or gain, or those with the EU function used on them cannot be compared. Such waveforms are reset or changed to the panel setpoints listed below when the comparator area setting mode is entered. Notice that these panel setpoints will not be replaced by the previous conditions when the comparator area setting mode is exited from.

1) The offset is reset to 0%, and the gain to 1x.
2) The MAG/PHASE key in the DISPLAY section is set to MAG.
3) On the logarithmic vertical axis for magnitude spectrum display, the displayed dynamic range is 80 dB.
4) The horizontal axis is made linear for magnitude spectra.
5) Frequencies on the horizontal axis appear in units of kHz or Hz.
6) The EU function is turned off.
7) The horizontal axis for time display is set to 1x (512-point display).
8) Addition (+), subtraction (-), and differentiation and integration operations are turned off.

To enter the comparator area setting mode, select the AREA item in the COMP menu, and press the ITEM key. The CRT will display the messages shown in Fig. 8.5. (The comparator area setting mode cannot be entered if a stored waveform is being displayed.)

MOVE
M▲=↑
M▼=↓
I▲=→
I▼=←

AREA
→ 0

ON/OFF
OFF

MODE
PEAK

SET

QUIT

Fig. 8.5 Items of Comparator Area Setting Mode

Listed below are the contents of the items displayed for the comparator area setting mode.

Item	Variable	Contents
AREA	0 - 9	Select the comparator area.
ON/OFF		Choose whether or not to use the comparator area (specified in AREA) with the comparator.
	OFF	The comparator area is not used with the comparator.
	ON	The comparator area is used with the comparator.
MODE		Select the manner of comparison with the comparator area specified in AREA.
	LEVEL	Level comparator
	PEAK	Peak comparator
	Poa	Partial overall comparator
SET		Set the comparator area.
QUIT		Leave the comparator area setting mode and return to the normal mode.

The items of the comparator area setting mode are selected with the COMSET and NEXT keys. The variables of the items are changed with the ITEM key.
To set the comparator area, operate keys as follows:

(1) Select the AREA item of the comparator area setting mode with the COMSET and NEXT keys. Specify an appropriate number with the ITEM key.

(2) Press the NEXT key to select the ON/OFF item. Set the ON/OFF item to ON with the ITEM key. (With MARKER set to ON in the COMP menu, a rectangular area appears on the screen.)

(3) Press the NEXT key to select the MODE item. Select one from among LEVEL, PEAK and Poa.

(4) Press the NEXT key to select the SET item. Press the ITEM key, and a rectangular area appears on the screen.

(5) Just as the area is displayed, the area values in the X direction (horizontal) and Y direction (vertical) are indicated in the upper part of the screen. With the area, X value and Y value displayed, the area can now be magnified, contracted or moved. These operations are switched over with the NEXT key. The Message "EXPAND" appears in the top right corner of the screen for magnifying or contracting, and "MOVE" appears in the same position for moving.

(6) Manipulate the comparator area as desired with the MENU (▲▼)keys, the ITEM (▲▼) keys and the NEXT key.

- Magnifying and contracting the area (EXPAND)
  - Operate the MENU (▲) key for magnification on the Y axis.
  - Operate the MENU (▼) key for contraction on the Y axis.
  - Operate the ITEM (▲) key for magnification on the X axis.
  - Operate the ITEM (▼) key for contraction on the X axis.

- Moving the area (MOVE)
  - Operate the MENU (▲) key for upward movement.
  - Operate the MENU (▼) key for downward movement.
  - Operate the ITEM (▲) key for rightward movement.
  - Operate the ITEM (▼) key for leftward movement.

(7) After the area is manipulated as desired, press the COMPSET key.

(8) Now the area has been set up.

(9) Up to 10 desired areas may be set by repeating the above steps (1) through (8).

After an area is set, the ON/OFF and MODE items can be changed. With the ON/OFF item set to OFF, the set area is still retained. When the necessary areas have been set up, select the QUIT item, and press the ITEM key to leave the comparator area setting mode. This completes the comparator area setting procedure.

8.5.3 Executing the Comparator

To execute the comparator, operate key switches as follows:

1) Select FREE or SNGL under the MODE item of the COMP menu. FREE is for continuous comparator execution, and SNGL is for single-shot comparator execution.
2) To display the comparator area(s), set MARKER to ON.
3) Set the ON/OFF key to ON (LED on) in the COMP section. The screen will change to the comparator execution mode.
4) Press the START key (LED on), and the comparator is executed.

The result of the compare operation is given by the LED, screen, and relay indications. To stop the comparator halfway, set the ON/OFF key to OFF (LED off).

- Executing the comparator on averaging waveforms
  Get an averaging waveform displayed, enter the comparator area settting mode, and set a comparator area(s).
  Entering the comparator execution mode automatically calls up an averaging waveform screen. Press the START key switch, and the previously executed averaging will again be executed. When the averaging operation is performed as many times as set, a compare operation is carried out.

CHAPTER 9. HOW TO USE THE PRINTER

If you have a printer installed, read the instructions below. Select the OPTN menu with the MENU (▲▼) keys in the SETUP section of the panel. Then select PRINTER using the ITEM (▲▼) keys. If the printer unit is properly connected, the items shown in Fig. 9.1 will appear.

```
  AVRG
  TRIG
  SCAL
  FUNC
  COMP
  WIND
→OPTN
  SENS
  FREQ

→PRINTR

 MODE
  HARDC

 EVNT
  OFF

 SET
```

Fig. 9.1

If message "NOT AVAIL" appears instead of the items in Fig. 9.1, the printer is not properly connected. Refer to 12.1, "Installing the Unit" and perform checkups.

Printer operations are specified by selecting the contents of each item in the OPTN menu, and are controlled using the keys in the PRINT section.

The printer is explained in three parts:

9.1 "PRINTER Items in OPTN Menu,"

9.2 "Setting the Time and Counter, and Specifying the Uni-directional or Bi-directional Printer Head Movement," and

9.3 "Printer Control."

9.1 PRINTER Items in OPTN Menu

As with the other menus, the items in the OPTN menu are changed and selected using the COMPSET, NEXT and ITEM (▲▼) keys.

(1) MODE

Select the type of printout.

- HARDC : Hard copy of the screen is available. All characters and waveforms displayed on the CRT are printed out.

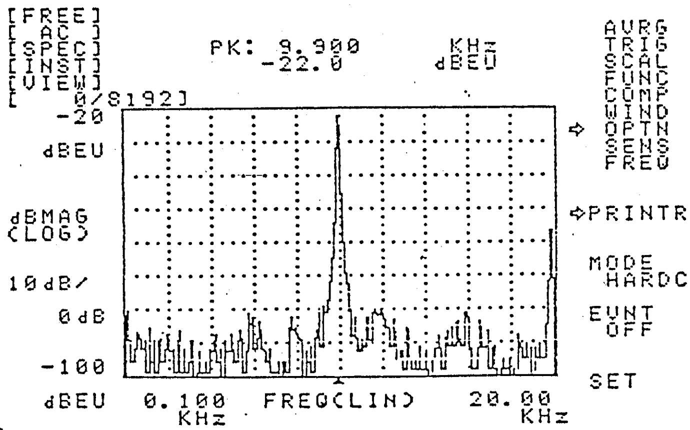

Fig. 9.2 Example of Hard Copy

- PARAM : A parameter list is printed out (Fig. 9.3).
- H + P : A screen hard copy is printed out, followed by printing of a parameter list.

--------- Parameter list ---------

DISPLAY	DOMAIN	SPECTRUM	
	AV/INST	INSTANT	
	VIEW/MEM	VIEW	
	MAG/PHASE	MAGNITUDE	
	X-LIN/LOG	LINEAR AXIS	
	Y-LOG/LIN	LINEAR AXIS	
	GRATICULE	ON	
	HARMONICS	OFF	
	CSR /.FRM	FRAME	
	DELTA	OFF	
	POS/GAIN	GAIN	
	COUPLING	AC	
	COMP	OFF	
AVERAGE	NUMBER	8192	
	MODE	NORMAL SUM	
	DOMAIN	SPECTRUM	
	RESTART	OFF	
TRIGGER	LEVEL	0	
	POSITION	0	
	SLOPE	⇧	
	SOURCE	INTERNAL	
SCALING	FREQ UNIT	Hz	
	SCALING	OFF	
	V / Vr	RMS	
	TIME	x 1	
	SPECTRUM	V^2	
FUNCTION	MODE	OFF	
	Int.Dif.	OFF	
	OVER ALL	OFF	
WINDOW	FILTER	ON	
	BUZZER	ON	
	WINDOW	HANNING	
	HARMONICS	THD	
	SPEED	SLOW MODE	
COMP.	MARKER	OFF	
	COMP MODE	FREE	
AREA0	ON/OFF	OFF	
	MODE	PEAK	
	UP LMT	781.2	Vr^2
	LOW LMT	625.0	Vr^2
	LEFT LMT	9.000	KHz
	RIGHT LMT	11.00	KHz
AREA1	ON/OFF	OFF	
	MODE	PEAK	
	UP LMT	781.2	Vr^2
	LOW LMT	625.0	Vr^2
	LEFT LMT	9.000	KHz
	RIGHT LMT	11.00	KHz
AREA2	ON/OFF	OFF	
	MODE	PEAK	
	UP LMT	781.2	Vr^2
	LOW LMT	625.0	Vr^2
	LEFT LMT	9.000	KHz
	RIGHT LMT	11.00	KHz
AREA3	ON/OFF	OFF	
	MODE	PEAK	
	UP LMT	781.2	Vr^2
	LOW LMT	625.0	Vr^2
	LEFT LMT	9.000	KHz
	RIGHT LMT	11.00	KHz
AREA4	ON/OFF	OFF	
	MODE	PEAK	
	UP LMT	781.2	Vr^2
	LOW LMT	625.0	Vr^2
	LEFT LMT	9.000	KHz
	RIGHT LMT	11.00	KHz
AREA5	ON/OFF	OFF	
	MODE	PEAK	
	UP LMT	781.2	Vr^2
	LOW LMT	625.0	Vr^2
	LEFT LMT	9.000	KHz
	RIGHT LMT	11.00	KHz
AREA6	ON/OFF	OFF	
	MODE	PEAK	
	UP LMT	781.2	Vr^2
	LOW LMT	625.0	Vr^2
	LEFT LMT	9.000	KHz
	RIGHT LMT	11.00	KHz
AREA7	ON/OFF	OFF	
	MODE	PEAK	
	UP LMT	781.2	Vr^2
	LOW LMT	625.0	Vr^2
	LEFT LMT	9.000	KHz
	RIGHT LMT	11.00	KHz
AREA8	ON/OFF	OFF	
	MODE	PEAK	
	UP LMT	781.2	Vr^2
	LOW LMT	625.0	Vr^2
	LEFT LMT	9.000	KHz
	RIGHT LMT	11.00	KHz
AREA9	ON/OFF	OFF	
	MODE	PEAK	
	UP LMT	781.2	Vr^2
	LOW LMT	625.0	Vr^2
	LEFT LMT	9.000	KHz
	RIGHT LMT	11.00	KHz

SENSE	RANGE	+30dBV
FREQUENCY	RANGE	20KHz
	A/D CLOCK	INTERNAL
OPTION	(PRINTER)	AVAILABLE
PRINT	EVENT	OFF
	MODE	PARAMETER
	COUNTER	OFF
	TIME	OFF
	DATE	OFF
OPTION	(GP-IB)	AVAILABLE
GP-IB	ADDRESS	0
	DELIMITER	CR+LF+EOI
OPTION	(MEMORY)	AVAILABLE
ZOOM	ENABLE	MAX x32
	CONTROL	STOP
	MAGNITUDE	x 2
	CENTER	0
	FRAME	0
OCTAVE	CONTROL	STOP
	RANGE	HIGH
	A-WEIGHT	OFF
3-D	ENABLE	ON
	CONTROL	STOP
	VIEW/MEM	VIEW
	MEM TOP	0
	ANGLE	LOW 2
	LINE NO.	16
MEMORY 0	ID. NUMBER	0
	PROTECT	OFF
		NOT USED
MEMORY 1	ID. NUMBER	0
	PROTECT	OFF
		NOT USED
MEMORY 2	ID. NUMBER	0
	PROTECT	OFF
		NOT USED
MEMORY 3	ID. NUMBER	0
	PROTECT	OFF
		NOT USED
MEMORY 4	ID. NUMBER	0
	PROTECT	OFF
		NOT USED

Fig. 9.3
Example of
Parameter List

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(2) EVNT

When the process specified in this item is completed, the data specified in the MODE item is automatically printed out.

- OFF : THE EVNT function is turned off.
- SMPL : With SMPL selected, the hold state is entered. Data from 512 points is sampled, and printed out every time the process set on the panel performs one pass.
- AVRG : When averaging is completed, the result is printed.
- COMPNG : With the comparator processing completed, the result is printed if it is NG.
- COMP : The result is printed out every time the comparator processing is completed.

Note : To stop the printout of an event halfway, press the FEED key in the PRINT section. The printer operation will stop.

(3) Set the SET item, press the ITEM (▲▼) keys, and the time/counter setting mode is entered (see 9.2).

9.2 Setting the Time and Counter, and Specifying the Uni-directional or Bi-directional Printer Head Movement

A built-in clock in the printer may be set, the initial value may be set on the hard copy printout counter, and other settings can be made.
Select the SET item in the OPTN menu, press the ITEM (▲▼) key, and the printer setting mode is entered. The screen shown in Fig. 9.4 will appear on the CRT.

```
                                          Hours        Month
                                            |  Minutes   |  Day
                                            |   | Seconds|   |  Year
                                            ↓   ↓   ↓    ↓   ↓   ↓
                                           13: 41: 28   12/02/85
 →DATA PRINT     [OFF]
  DATA SET       00/00/00              (MM/DD/YY)
                 ↑
  TIME PRINT     [OFF]
  TIME SET       00: 00: 00            (HH: MM: SS)
                 ↑
  COUNTPRINT     [OFF]
  COUNTSET       0000
                 ↑
  BIDIRECTION    [BOTH]
  END
```

Fig. 9.4

Each of the displayed items may be selected with the MENU (▲▼) keys, and changed or set up using the NEXT key.

- Explanation of displayed items

DATE PRINT : Choose whether or not to print out the set date in hard copy.
OFF: Date not printed
ON : Date printed

DATE SET : Select this item when setting the date. See "Setting the date, time, and hard copy printout count" below for the setting procedure.

TIME PRINT : Choose whether or not to print out the set time in hard copy.
OFF: Time not printed
ON : Time printed

TIME SET : Select this item when setting the time. See "Setting the date, time, and hard copy printout count" below for the setting procedure.

COUNTPRINT : Choose whether or not to print the hard copy printout count in hard copy.
OFF: Hard copy printout count not printed
ON : Hard copy printout count printed
The hard copy printout is incremented only when the COUNTPRINT item is set to ON. If hard copy printout is stopped halfway, the hard copy printout count is not incremented. This count is retained when power is off.

COUNTSET : Select this item when setting the initial value of the hard copy printout count. See "Setting the date, time, and hard copy printout count" for the setting procedure.

BIDIRECTION : BOTH : Hard copy is printed bi-directionally.
SNGL : Hard copy is printed uni-directionally.
* Bi-directional printing (BOTH) completes hard copy about twice as fast as uni-directional printing (SNGL). But the quality of bi-directional printing is a little lower than that of uni-directional printing.

END : Select this item when leaving the setting mode and returning to the usual mode.
Strike the NEXT key.

- Setting the date, time, and hard copy printout count
  Select the DATE SET, TIME SET and COUNTSET using the MENU (▲▼) keys. Input the desired numerals with the numeric keys.

DATA SET   09 / 24 / 85 (Sept. 24, 1985)
    ↑ Month 01-12, ↑ Day 01-31, ↑ Year
    (The year is not incremented on New Year's Day.)

TIME SET   14 : 32 : 58 (14 hr. 32 min. 58 sec.)
    ↑ Hours 00-23, ↑ Minutes 00-59, ↑ Seconds 00-59

COUNTSET   1 2 3 4
    0000-9999
    (The count is reset to 0 upon reaching 10000.)

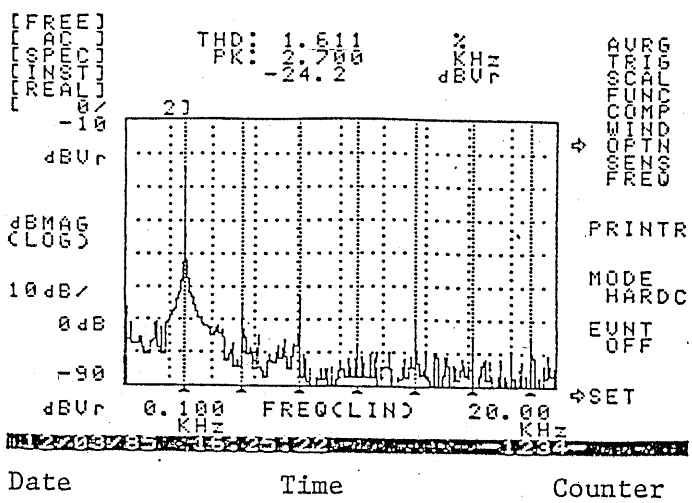


Fig. 9.5 Example of Date, Time and Counter Printed Out

9.3 Printer Control

The printer is controlled with the keys in the PRINT section.

- Operate the COPY key to print out screen hard copy and parameter lists.
- Operate the FEED key to feed paper or stop printing.

During printing, all other processing is suppressed.

CHAPTER 10. GP-IB OPERATION

10.1 Outline

The GP-IB interface is an internationally recognized interface that connects multiple measuring instruments and controllers. This option provides an interface coupling the GP-IB (IEEE 488-1978) with the FFT analyzer.
When connected to this option, the FFT analyzer can send data and receive instructions to and from other measuring instruments and computers.
Devices and instruments configured around the GP-IB as their core readily constitute a system that is fully programmable in a remote control environment.

Below are the major functions that can be implemented with the GP-IB intrface installed.

(1) Pannel control
The FFT analyzer can be controlled by an external talker via the GP-IB in the same manner as it is manually controlled by the use of keys on the front panel.

(2) Parameter readout
Measurement parameters defining the FFT analyzer's operation status are transferred to an external listener through the GP-IB.

(3) Cursor value readout
The cursor values displayed on the screen after calculations are transferred to the external listener through the GP-IB.

(4) Measured data readout
The results measured by the FFT analyzer are transferred in binary data blocks to the external listener through the GP-IB.

(5) Returning of transferred data
Some of the data transferred to the external listener (in

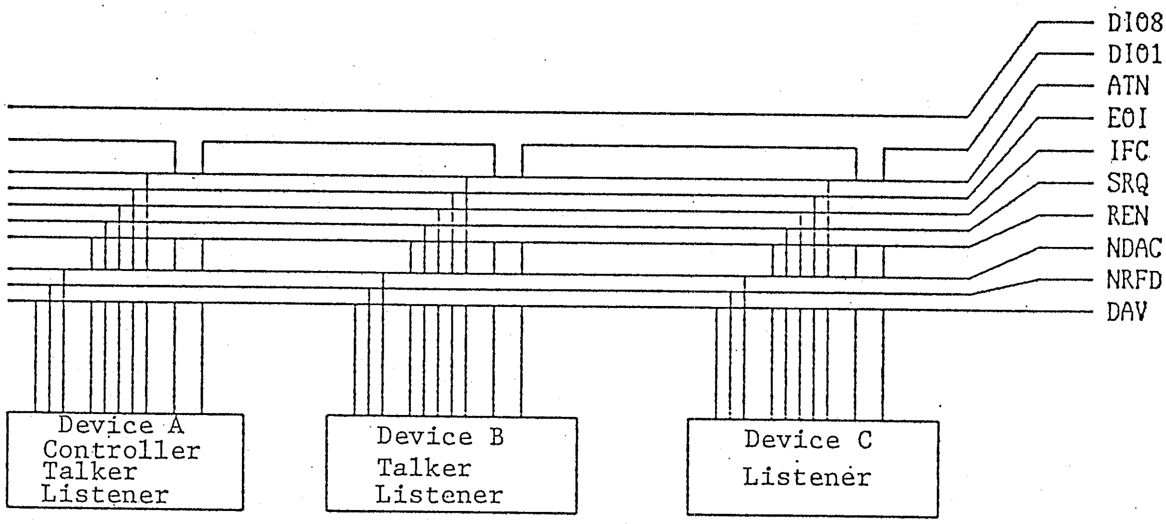
(4) above) can be sent back to the FFT analyzer for display.

(6) Service request transmission
Upon comparator NG or averaging end, an SRQ is transmitted to an external controller.

The GP-IB stands for "General Purpose Interface Bus."
It is an interface that interconnects multiple measuring instruments of different makes or capabilities.

Signals are transmitted over bi-directional bus on a bit parallel (8-bit), byte serial basis. Data is transmitted through a three-line handshake arrangement. Measuring instruments are connected in parallel on the common signal lines. Because the but operates asynchronously, data is transmitted without error between devices of different transmission speeds. The slowest device governs the transmission speed.
Each of the devices connected on the bus may assume the function of a talker, a listener or a controller, or of any combination of the three.
Data is transferred from a device designated as talker to one or more devices designated as listener. The controller controls interface functions as well as the transmission and reception of data between the devices connected on the bus.
The bus consists of 8 data lines, 3 handshake lines and 5 bus control lines plus a ground line.

In the sketch following, the data lines are DI01 through DI08; the handshake lines are NDAC, NRFD and DAV: and the bus control lines are ATN, EOI, IFC, SRQ and REN.


DI08
DI01
ATN
EOI
IFC
SRQ
REN
NDAC
NRFD
DAV
Device A
Controller
Talker
Listener
Device B
Talker
Listener
Device C
Listener

873496

10.2 Specifications

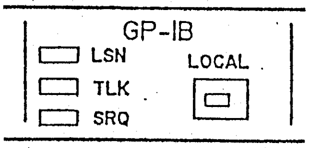
- Applicable standard : IEEE 488-1978
- Addressing system : One of No. 0 to 30 is selected on the DIP switch at the rear panel.
- Delimiter specification : Setpoint LF or CR + LF is selected on the DIP switch at the rear panel.

10.3 Interface functions

Code	Function
SHI	All SH functions provided
AHI	All AH functions provided
T6	Basic talker functions, serial polling, and listener-designated talker cancel function provided
L4	Basic listener functions, and talker-designated listener cancel functions provided
SRI	Service request function provided
RLI	Remote function provided
PPO	Parallel polling not provided
DCI	Device clear function provided
DTO	Device trigger function not provided
CO	Controller function not provided

10.4 Handling the GP-IB Interface

10.4.1 Front Panel Controls



Front panel

At bottom center of the front panel is the area for indicating how the GP-IB is operating (see sketch). The LEDs show the current operating status of the GP-IB in the FFT analyzer.

(1) LEDs

- o LSN : Lights when the analyzer is designated as listener, and goes off when the designation is canceled.
- o TLK : Lights when the analyzer is designated as talker, and goes off when the designation is canceled.
- o SRQ : Lights when the anlyzer transmits an SRQ, and goes off when the analyzer is designated as listener after the status byte is read during serial polling.

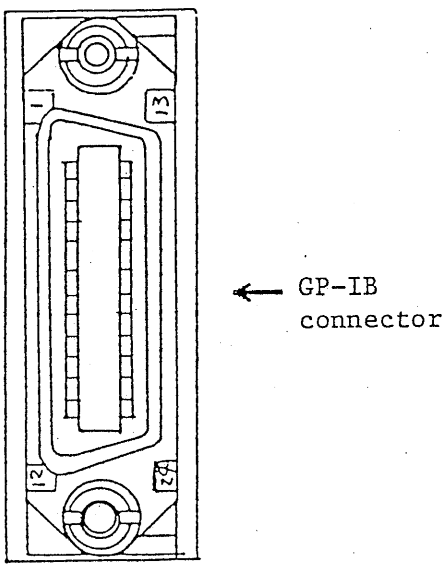
(2) Switch

This switch is used to change the FFT analyzer from remote state to local state. When the analyzer is placed in the remote state by an external controller through the GP-IB, the keys on the front panel become inoperable. At this time, this switch may be pressed if it is desired to place the analyzer in the local state for control from the front panel. Notice that this switch is also inoperable if the analyzer is placed in the LLO (local lockout) state. The LED of the switch lights in the local state and goes off in the remote state.

10.4.2 Menus

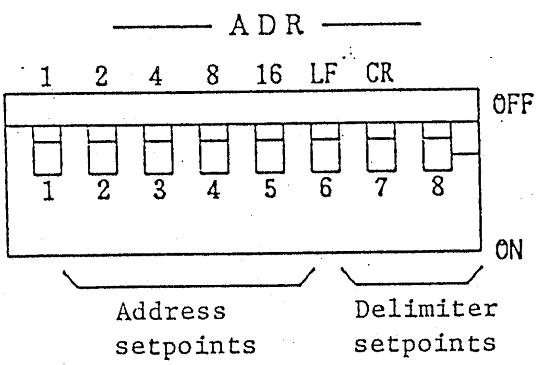
→ GP-IB	The current address and delimiter setpoints of the FFT analyzer can be displayed on the screen for verification.
ADRS 7	To display the menu shown on the left, position the menu cursor to the option item, and keep pressing the ITEM key until the GP-IB item display appears.
DLMTR CR LF EOI	The contents displayed here are for verification only; they cannot be modified.

10.4.3 Rear Panel Controls



At the rear panel of the FFT analyzer are the GP-IB connector (see sketch) and the DIP switch for setting the address and delimiter.

Use the DIP switch under the GP-IB connector when selecting the FFT analyzer's address for the GP-IB as well as the delimiter for data transmission.



(1) Setting address

An address is determined by the combination of lower 5 setpoints on the DIP switch. The allowable address range is from 0 to 30.

Each numbered setpoint on the DIP switch adds its numeral to the address when set to ON. The address is 0 if all the setpoints are set to OFF. For example, address 19 may be divided into 19 = 16 + 2 + 1. So the setpints 16, 2 and 1 are set to ON.

GP-IB Connector Pin Arragement

Pin No.	Pin name	Pin No.	Pin name
1	DIO1	13	DIO5
2	DIO2	14	DIO6
3	DIO3	15	DIO7
4	DIO4	16	DIO8
5	EOI	17	REN
6	DAV	18	GND
7	NRFD	19	GND
8	NDAC	20	GND
9	IFC	21	GND
10	SRQ	22	GND
11	ATN	23	GND
12	SHIELD	24	GND

The address set on the DIP switch is read once by the FFT analyzer upon power-up. That is, the address or delimiter will not be changed if the DIP switch is manipulated while power is on. To get a new address or delimiter, change the setting, remove power, and apply it again.

(2) Setting the delimiter

One of three delimiters may be used for the FFT analyzer.

1) EOI
2) LF + EOI
3) CR + LF + EOI

(CR stands for "carriage return code," LF for "line feed," and EOI for "end or identify.")

The delimiter is set by the DIP switch under the GP-IB connector at the rear panel.

The delimiter setpoints on the DIP switch are marked "CR" and "LF." Each setpoint enables its corresponding characters as the delimiter when set to ON. Notice that setting the "CR" setpoint alone to ON is not allowed. During binary data block transmission, delimiter "EOI" is always selected regardless of the setting made here.

		Switch setting			
Setpoint name	"CR"	ON	OFF	ON	OFF
	"LF"	ON	ON	OFF	OFF
Delimiter		CR+LF+EQI	LF+EOI	Not allowed	EOI

Handshaking is terminated whenever "EOI" is admitted, even if some setpoint other than "EOI" is also specified. Use "EOI" in all cases; without it, the transmission sequence will not be terminated.

CAUTION:

1. Before connecting the cables and powering the system for operation, be sure to set the delimiter and address.
2. If other devices are connected on the bus, keep these devices powered during operation even if they are not used.
3. Up to two piggyback connectors may be stacked upright at a single location.
4. Comply with all the other requirements under IEEE 488-1978.

10.5 Device Functions

10.5.1 Functions Enabled by Device Messages

Setting up this interface allows device messages to enable the following functions:

1) Controlling the panel
2) Reading the parameters
3) Reading the cursor values
4) Reading the measured data
5) Returning the transferred data

(1) Controlling the panel

The FFT analyzer can be controlled by an external controller through the GP-IB in the same manner as it is manually controlled by the use of keys on the front panel. The controllable operations include setting measurement conditions, starting the analyzer and others.

For example, to set the frequency range for 20 kHz, the controller transmits character string "FRQ 13" to the analyzer. On receipt of these characters, the analyzer interprets the message and sets the frequency ranges for 20 kHz. Next time the analyzer is designated as talker, it returns the character string corresponding to the operation it performed.

(2) Reading the parameters

The conditions under which the FFT analyzer performs measurement and the operating status of the analyzer are transmitted to an external computer or other device.

For example, if it is desired to know the analyzer's current frequency range, the FRQ command (used in (1) above), followed by symbol '?' in place of a numeric parameter, is transmitted to the analyzer. On receipt of character string "FRQ?," the analyzer interprets the message, reads the current frequency range out of its storage, and turns the range to an appropriate numeral, and sends it back next time the analyzer is designated as talker.

(3) Reading the cursor values

The readout of peak values, cursor values, etc., usually displayed on the analyzer screen, is transmitted to an external computer or other device. The data is transmitted in one of two formats.

In one transmission format, displayed values are transmitted almost as they are. In their original form, these values are difficult to admit and operate on. But having the data displayed virtually the same way on the external computer as on the analyzer screen is very convenient for display purposes.

In the other transmission format, readout units and headers are converted to numerals before they are transmitted. Computed values are converted to exponentially represented floating-point numbers. These are the values of the same unit irrespective of range.

The latter format offers the advantage of simple format conversion when an external computer receives computed values as numbers.

Notice that these values, when displayed unchanged, take on a format different from that of the readout on the FFT analyzer. Some modifications are needed.

For example, when a peak value is displayed on the analyzer screen, the external computer can read it by sending "RCSO" to the analyzer. After receiving character string "RCSO," the analyzer interprets the message, and sets its peak value in the talker buffer. Next time the analyzer is designated as talker by the controller, the peak value is sent out.

(4) Reading the measured data

The FFT analyzer has 512 points of time data, 201 points of spectrum data, and 128 points of histogram data inside. These data can be transmitted as binary block data to an external computer or other device. The data stored in the analyzer's panel memory and screen memory can also be transmitted in binary data blocks to the outside. This capability allows huge quantities of measured data to be transferred from the screen and panel memory to external files.

If it is desired to read time data, the analyzer's display screen is switched to the time waveform display.

Character string "WDD?" is then sent to the analyzer.

On receipt of "WDD?," the analyzer sets the currently displayed waveform data in the talker buffer. Next time the analyzer is designated as talker by the external controller, etc., the time data is sent out in binary data blocks.

(5) Returning the transferred data

The data transferred to an external computer, etc. (in (4) above) is stored in memory or files of the device that received it. The data can be returned to the FFT analyzer for display and operations. This function is available only with screen memory data and panel data.

In addition, the analyzer may be placed in the hold state so that it can accept time data from the outside. This feature makes it possible to display the spectrum based not on actually measured data but on calculated time data.

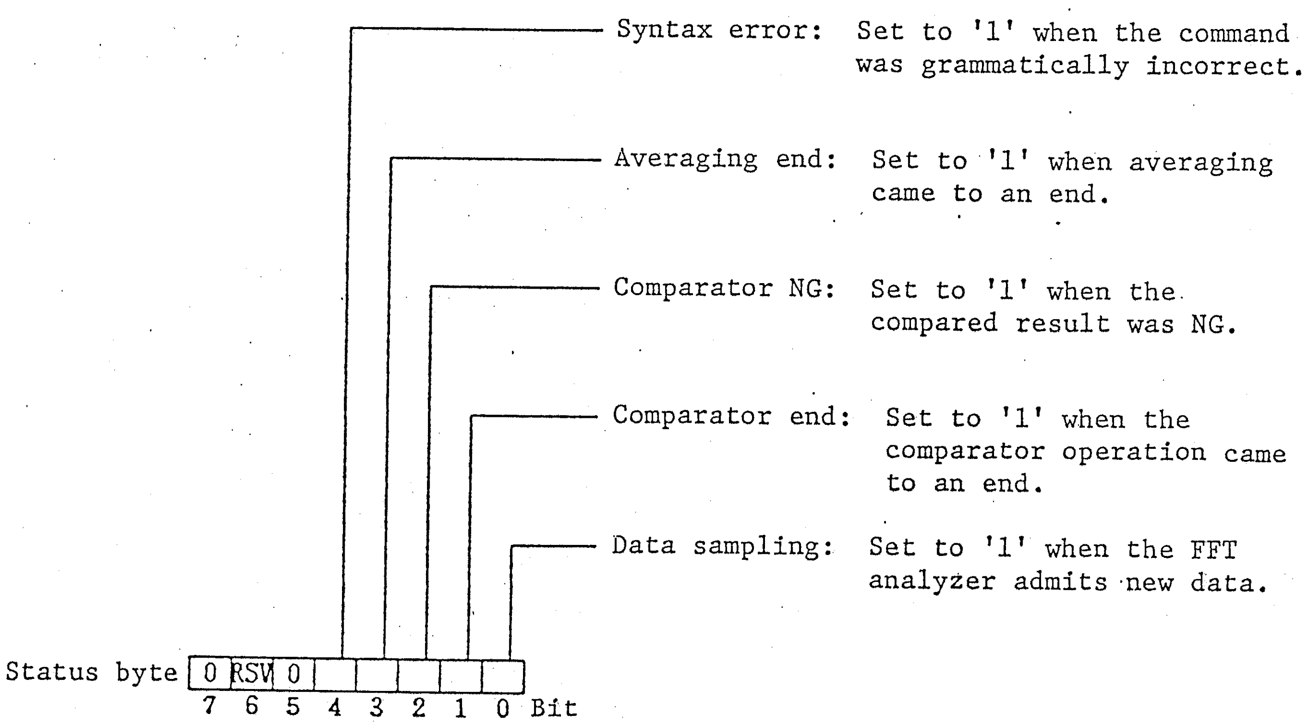
The format in which data is returned comprises a three-character command, followed by binary data. For more information, refer to 10.7.2, "Talker Formats."

10.5.2 Device Trigger and Device Clear

Sending a device trigger signal to the FFT analyzer does not affect it in any way. On receipt of a device clear signal, the analyzer clears the status byte, and sets character string "DEVICE CLEAR RECEIVED!" in the talker buffer.

10.5.3 Handling the SRQ

The FFT analyzer may transmit an SRQ to an external controller, informing it of what has happened inside the analyzer.
When the SRQ is transmitted, each cause of the occurrence is assigned one bit of the status byte. Each bit is set to '1' if applicable. the controller is able to know what happened in the analyzer by reading out the status byte.
Transmission of the SRQ is suppressd when power is applied. To enable SRQ transmission requires issuing an SQMn" command.
Below are the bits of the status byte, keyed to each cause of what occurred in the analyzer.

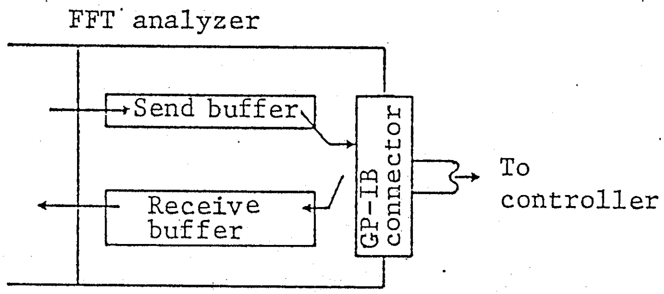


These bits, keyed to the causes that may trigger SRQ transmission, are usually zero. When a phenomenon occurs, the corresponding bit is set to '1'. SRQ transmission, resulting from any of the bits being set to '1', can be individually inhibited or enabled by changing the contents of the SRQ mask register. The bit arrangement in the SRQ mask register is the same as in the status byte. Setting a bit in the register to '1' enables the corresponding SRQ transmission; setting the bit to '0' inhibits the transmission. All the bits of the status byte are set to zero upon power-up. All SRQ transmission is inhibited when power is applied.

Bits 0-4 in the status byte are cleared when the analyzer is designated as listener after serial polling. The RSV bit is cleared immediately after serial polling.

10.6 Data Exchange Sequence

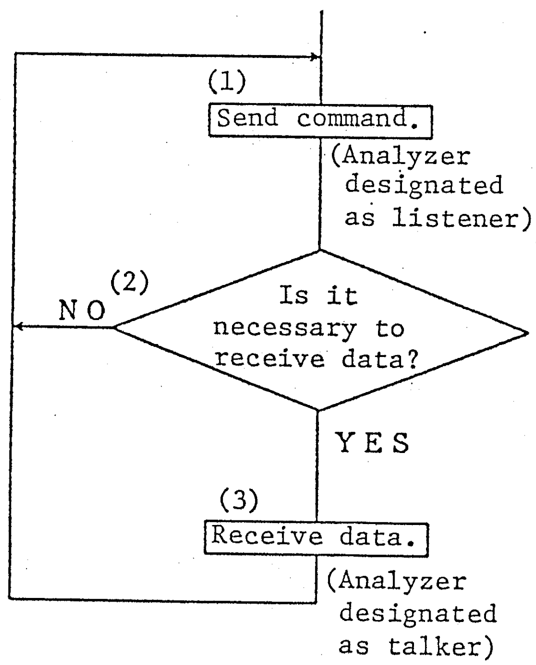
The GP-IB in the FFT analyzer has a send buffer and a receive buffer.
The data sent from the outside (computer, etc.) enters the receive buffer, and the data to be sent out enters the send buffer.



From an outside point of view, data is written to and read from the analyzer's buffers by designating the analyzer as listener and talker, respectively.

Because data is always held in the buffers, there is no timing at which data must not be sent out or must be received.

Explained below is the basic sequence in which the FFT analyzer is controlled through the GP-IB.



(1) Command sent to FFT analyzer
The command received via the GP-IB enters the receive buffer of the FFT analyzer. The analyzer reads the contents of the buffer, acts accordingly, and writes the result into the send buffer.

(2) Returning to step (1) if data need not be received

The processing returns to step (1) above if there is no need to receive the result of the command sent to the analyzer.

(3) Receiving data

With the command sent in step (1), the analyzer's send buffer contains the data corresponding to the command. For example, where cursor value readout command "RCS" was sent to the analyzer, its send buffer contains a cursor value. Where a command with '?' attached as parameter was sent, the analyzer's send buffer contains the parameter value corresponding to that command. If an error occurred, the send buffer contains the corresponding error message.

Designating the analyzer as talker makes it possible to receive the data. If the data is not needed, there is no need to designate the analyzer as talker.

The send buffer is updated every time a command is executed. This means that when multiple commands were sent to the analyzer, its send buffer contains the data corresponding to the last command. If the analyzer is designated consecutively as talker, the same data in the send buffer is continuously transmitted.

If a command with a numeral attached to it is followed immediately by the same command with '?' suffixed during multiple command transmission to the analyzer, the parameter obtained is the preceding value.

Example: With a spectrum displayed, transmit the command "VIW 1 VIW?"
and the screen will switch to a time waveform display. Here, the parameter that is read by "VIW?" command is 1.

If it is desired to get the correct parameter by sending "VIW?" following "VIW1," separate the two commands. Do not sent the two as a single character string.

Error messages

If a grammatically incorrect command is sent to the FFT analyzer, the corresponding error message is set in the analyzer's talker buffer. That is, the cause of a grammatical error, if one happens, is known by reading the message out of the talker buffer. Notice that the message is not always relevant to each particular error, because these messages only indicate broad categories of numerous error causes.

- "Command Error! Command not found"
  This error message is output if the command that came in had no part that could be interpreted as a command.

- "Command Error! 2 or 1 character command received"
  This error message is output if the command that came in contained 1 or 2 characters. All FFT analyzer commands consist of 3 characters each.

- "Command Error! Command not registered"
  This error message is output if the command that came in was not an FFT analyzer command.

- "Parameter Error! Value not proper"
  This error message is output if the parameter value was not the legitimate value corresponding to the command.

- "Parameter Error! Parameter not found"
  This error message is output if there was no parameter.

- "Execute Error! Not executed because of inhibited status"
  This error message is output if the command was not executed for some reason. For example, a command is not executed if an attempt is made to change the frequency range in the hold state.

- "Delimiter Error! Not CR code"
  This error message is output if delimiter code "CR" was absent when delimiter "CR + LF + EOI" was selected.

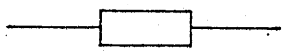
- "Delimiter Error! Not LF code"
  This error message is output if delimiter code "LF" was absent when delimiter "LF + EOI" was selected.

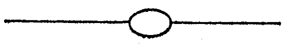
Note: Perform communication via the GP-IB when the FFT analyzer is not in a setting screen state. With the analyzer in the setting screen state, exchanging data through the GP-IB may alter the displayed contents. Setting screens include the screen for setting comparator areas, and that for setting printer option items, time and date.

10.7 Listener and Talker Formats

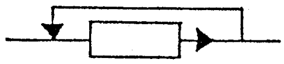
10.7.1 Command and Syntax Structures

Commands and their corresponding parameters are transmitted as send data to the FFT analyzer for operation control.
In the paragraphs that follow, syntax structure drawings are used to explain the structures of commands and parameters. A syntax structure drawing comprises the following elements:

1)  A rectangular symbol represents each data item.

2)  A round symbol represents character data, such as an ASCII character.

3)  An arrow indicates the sequence in which contiguous data items are connected.

4)  A feedback loop indicates the repeat of one or more data items.

(1) Send data structure

[Command train] [Delimiter] [Send data]

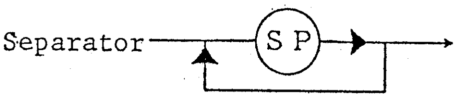
A command train is a one-byte data train consisting of ASCII or binary codes. One of three delimiter is selected: CR + LF + EOI, LF + EOI, or EOI. A single command train may be up to 1500 bytes in length.

(2) Command train structure

[Command block 1] [Separator] [Command block 2] [Separator] --
----- [Separator] [Command block n] [Command chain]

A command train consists of one or more command blocks. Where a single command is to be sent, the command train contains only one command block.

Command blocks are divided by separators. A separator is a space code made up of one or more characters.



SP: Space code

(3) Command block structure

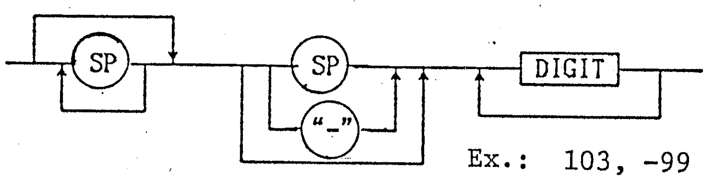
Command | Separator | Parameter [Command block]

A command block consists of a command, a separator and a parameter. A command is made up of a three upper-case alphabetical character code.

Command: Alphabetical character | Alphabetical character | Alphabetical character

Parameters: There are four finds of parameter.

1) Numeric parameter:
This parameter is a combination of a minus sign (-), numerals '0' through '9' and a space(s), representing a signed integer.



Ex.: 103, -99

Some commands may need multiple numeric parameters. In such cases, arrange in order as many numeric parameters as needed, and have them separated from one another by separators.

Command (Separator) Parameter Separator Parameter ---

2) ? parameter:
The "?" code is used as a parameter.

3) @ parameter:
The "@" code is used as a parameter.

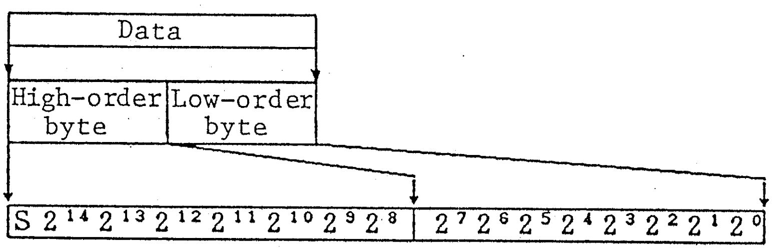
4) Binary data parameter:
Binary data may be transmitted to the FFT analyzer as a parameter in one of the following formats.

o BTM command

#	I	Data item 0	Data item 1	------ ------	Data item 511	

EOI
Total: 1026 bytes

The BTM command is a command that transmits time data to the FFT analyzer. A total of 512 data items are needed, each item composed of 2 bytes.
This means that the parameter is 1026 bytes long (512 x 2 + 2 = 1026).



Each data item consists of a sign bit plus 15 bits, or a 16-bit twos complement representing an integer.

o BPL command

#	I	0	n	Data item 0	Data item 1	----- -----	Data item 419

$0 \lesssim n \lesssim 9$
Total: 424 bytes

A BPL command needs 420 data items, each consisting of one byte. In the format above, "n" is a one-byte binary panel number. "0" preceded "n" is always zero of one-byte in binary format. That is, the parameter is 424 bytes long (420 + 4 = 424). Notice that $1 \leqq n \leqq 4$ if the expansion memory option is not provided, and $0 \leqq n \leqq 9$ if that option is provided.

- BMD command

#	I	0	n	Data item 0	Data item 1	------ -----	Data item 1443

$0 \leqq n \leqq 40$
Total: 1448 bytes

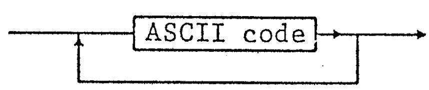
A BMD command needs 1444 data items, each consisting of one byte. In the format above, "n" is a one-byte binary memory number. "0" preceded "n" is always zero of one-byte in binary format. That is, the parameter is 1448 bytes long (1444 + 4 = 1448). Notice that n = 0 if the expansion memory option is not provided, and $0 \leqq n \leqq 40$ if that option is provided.

10.7.2 Talker Formats

Below are the formats that the FFT analyzer uses for sending data when designated as talker. Of the four data types described below, (1) through (3) are ASCII data, and (4) is binary data.

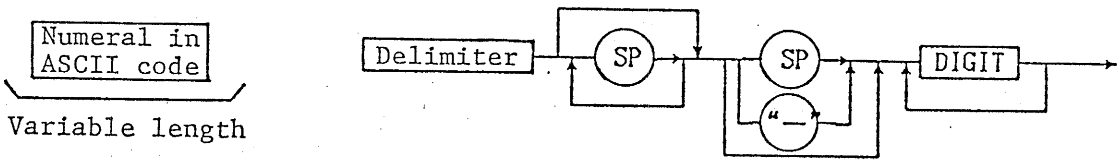
(1) Data to be sent when the analyzer is designated as talker immediately after a panel control command is transmitted.

ASCII code character string	Delimiter
Variable length	



Example: If the analyzer is designated as talker immediately after the "TST1" command is transmitted, the data is "TEST ON".

(2) Data to be sent when the analyzer is designated as talker immediately after a parameter read command is transmitted.



Example: If the analyzer is designated as talker immediately after the "VIW?" command is transmitted and if a spectrum is being displayed, the data is "0".

(3) Data to be sent when the analyzer is designated as talker immediately after a cursor value read command is transmitted
Cursor value data comes in two formats that may be switched by a CDP command. With "CDP0" transmitted, the cursor value is the same as that on the analyzer screen. With "CDP1" transmitted, the cursor value is formatted for computation. Cursor values vary in format depending on cursor type. RCS0 and RCS1 are the same in format, so are RCS2 and RCS3.

(A) Format of RCS0 and RCS1 with CDP0

CSR␣	Character string	,	XVL␣	X-axis value	,	YVL␣	Y-axis value	Delimiter

→ This character string represents the type of the data pointed to by the cursor. One of the following character strings applies here:

"+PK:"

"-PK:"

"CSR:"

"REF:"

"DLT:"

" PK:"

"INVL"

→ The X-axis value is the same in format as the X-axis value pointed to by the cursor on the screen.

10 bytes	8 bytes
Numeral	Unit

The area for containing a numeral is fixed to 10 bytes in length. Any unused bytes are padded with spaces. The area for containing a unit is fixed to 8 bytes in length. Any unused bytes are padded with spaces.

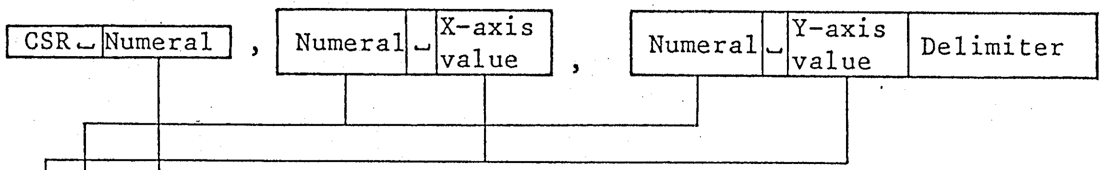
→ The Y-axis value is the same in format as the Y-axis value pointed to by the cursor on the screen.

10 bytes	8 bytes

The area for containing a numeral is fixed to 10 bytes in length. Any unused bytes are padded with spaces. The area for containing a unit is fixed to 8 bytes in length. Any unused bytes are padded with spaces.

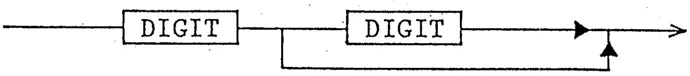
Example: CSR␣"+PK:",XVL␣␣0.914␣␣␣␣␣SEC␣␣␣␣,YVL␣␣1.514␣␣␣␣␣V␣␣␣␣␣␣␣

(B) Format of RCS0 and RCS1 with CDP1



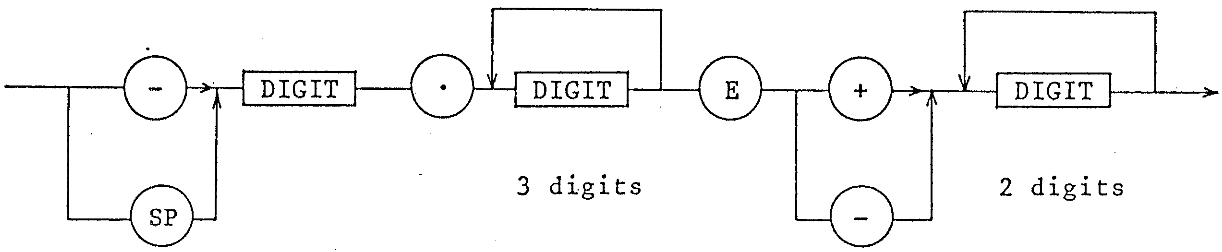
The numeral contained here as an unsigned one-digit integer represents the cursor type. Refer to 10.7.3 for the correspondence between numerals and cursor types.

The numeral contained here as an unsigned one- or two- digit integer represents the unit on the X- and Y-axes.



Refer to 10.7.3 for the correspondence between numerals and units for the X- and Y-axes.

X- and Y-axis values are exponentially represented here.



Example: ␣1.234E + 02

(C) Format of RCS2 and RCS3 with CDP0

CSR␣	Character string	,	VAL␣	Computed value	Delimiter

→ This character string represents the computed value type.

- "OVA:" or "PAR:" for RCS2
- "THD:" or "THP:" for RCS3

→ The computed value is the same in format as that displayed on the screen.

Numeral (10 bytes)	Unit (8 bytes)

The area for containing a numeral is fixed to 10 bytes in length. Any unused bytes are padded with spaces. The area for containing a unit is fixed to 8 bytes in length. Any unused bytes are padded with spaces.

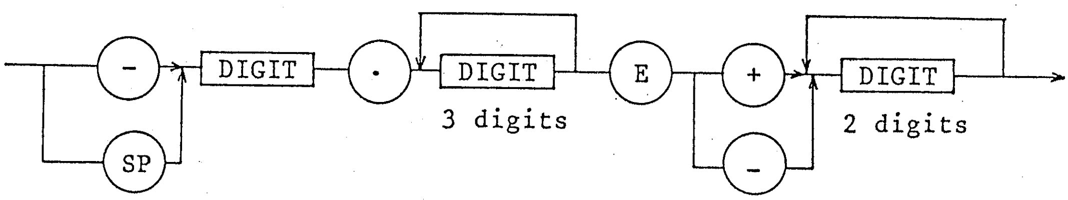
(D) Format of RCS2 and RCS3 with CDP1

CSR␣␣Numeral	,	Numeral␣	Computed value	Delimiter

→ The numeral contained here as an unsigned one-digit integer represents the computed value type. Refer to 10.7.3 for the correspondence between numerals and computed value types.

→ The numeral contained here as an unsigned one- or two-digit integer represents the unit of computed values. Refer to 10.7.3 for the correspondence between numerals and computed value units.

→ A computed value is exponentially represented here.



(4) Data to be sent when the analyzer is designated as talker immediately after receiving an observed data read command

When the FFT analyzer receives an observed data read command, its talker buffer is set with binary data. The set data varies in length depending on the type of the data to be transferred. Shown below are the lengths of various data types in bytes to be transferred.

1) Binary data to be transferred by "WDD" command

Note: "D item" indicates "Data item" in following figures.

a. With time data displayed

* Refer to 7.4 for how to convert data into physical quantities.

#	I	D item 0	D item 1		D item 509	D item 510	D item 511

(Time data)

Since each data item is 2 bytes long, we get:

2 + 512 x 2 = 1026 Total: 1026 bytes

Chronological progression of data is from data item 0 to data item 511.

b. With histogram data displayed

* Refer to 7.4 for how to convert data into physical quantities.

#	I	D item 0	D item 1		D item 125	D item 126	D item 127

(Histogram data)

Since each data item is 2 bytes long, we get:

2 + 128 x 2 = 258 Total: 258 bytes

Data item 0 is on the negative voltage side, and data item 127 is on the positive voltage side.

c. With magnitude spectrum data displayed

* Refer to 7.4 for how to convert data into physical quantities.

#	I	D item 0	D item 1		D item 198	D item 199	D item 200

(Power spectrum data)

Since each data item is 4 bytes long, we get:

2 + 201 x 4 = 806 Total: 806 bytes

Data item 0 represents DC, and data item 200 the maximum frequency data.

d. With phase spectrum data displayed

* Refer to 7.4 for how to convert data into physical quantities.

#	I	D item 0	D item 1		D item 198	D item 199	D item 200

(Phase spectrum data)

Since each data item is 2 bytes long, we get:

2 + 201 x 2 = 404 Total: 404 bytes

Data item 0 represents DC, and data item 200 the maximum frequency data

e. 1/3-octave data

* Refer to 7.4 for how to convert data into physical quantities.

#	I	Data 0		Data 27	Data 28

(1/3 octave data)

Refer to 7.4 for methods of converting data into physical quantity.

The total length of data stored in the talker buffer is calculated by

Leading bytes + Number of data items x Length of each data item = 2 + 29 x 4
= 118 (bytes)

Data item 0 is for the lowest frequency band and data item 28 is for the highest frequency band. The format of each 1/3-octave data is the same as that of the magspectrum data.

2) Binary data to be transferred by "PLD" command

#	I	D item 0	D item 1		D item 417	D item 418	D item 419

(Panel data)

Since each data item is 1 byte long, we get:
2 + 420 = 422 Total: 422 bytes

3) Binary data to be transferred by "MDD" command

#	I	D item 0	D item 1		D item 1441	D item 1442	D item 1443

(Memory data)

Since each data item is 1 byte long, we get:
2 + 1444 = 1446 Total: 1446 bytes

4) Sending harmonic data by the HML data

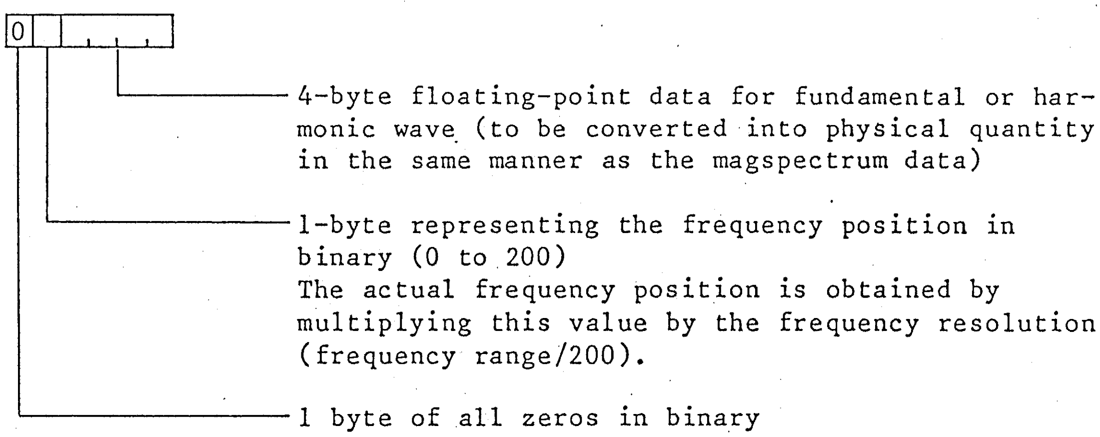
#	I	0	n	Data 1	Data 2		Data n

4 bytes

The number of data items to be read by the HML command depends upon the number of harmonic waves. When there are n harmonic waves, n pieces of data items are read and sent by the HML command. Data for the fundamental wave is always sent. The value of "n" is 1 to 11 since there are up to eleven harmonic waves available.
The third byte preceded by "#I" is all zeros (in binary). The size of the harmonic data sent by the HML command is expressed by

Leading bytes + Number of data items x Data item size = 4 + n x 6 (bytes)

That is, the size of the harmonic data varies according to the number of harmonic waves (10 bytes for n = 1 to 70 bytes for n=11). Data item 1, data item 2, ..., data item (n) respectively correspond to fundamental wave, second harmonic, third harmonic, ..., n-th harmonic waves in that order. Each data item is formatted:



10.7.3 Correspondence Between Numerals and Character Strings, Between Numeral and Units

(1) Table of correspondence between numerals and character strings

Numeral	Character string
0	+PK:
1	CRS:
2	REF:
3	-PK:
4	DLT:
5	INVL
6	PK:

(2) Table of correspondence between numerals and units

Numeral	Unit	Numeral	Unit
0	No unit	15	Vr
1	V	16	EU
2	Sec	17	dBEU
3	Hz	18	ORD
4	dB	19	Vr^2
5	dBV	20	EU^2
6	dBVr	21	$Vr/\sqrt{Hz}$
7	DEG	22	Vr^2/Hz
8	CPM	23	$EU/\sqrt{Hz}$
9	V^2	24	EU^2/Hz
10	$V/\sqrt{Hz}$	25	$dBEU/\sqrt{Hz}$
11	V^2/Hz	26	
12	%	27	
13	$dBV/\sqrt{Hz}$	28	
14	$dBVr/\sqrt{Hz}$	29	

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* Invalid cursor data

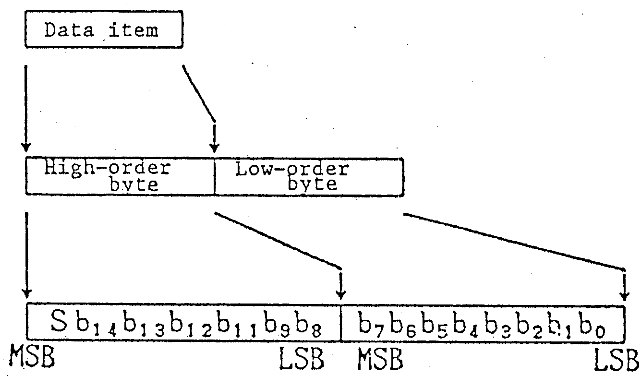
An attempt to read cursor values without the cursor displayed causes the following data to be returned:

- "IV 5, 00, 00" or "CSR "INVL", XVAL 0, YVAL 0" for RCS0 and RCS1
- "IV 5, 00" or "CSR "INVL", VAL 0" for RCS2 and RCS3

10.7.4 Converting Binary Data to Physical Quantities

The binary data sent out by the FFT analyzer are all normalized values; they are converted to physical quantities when a given range or function is multiplied by the corresponding coefficient.
The analyzer transmits four types of measured data: time data, histogram data, power spectrum data, and phase spectrum data.

(1) Time data
Each item of time data is 2 bytes long, represented in two's complement and transmitted high-order byte first, low-order byte second.

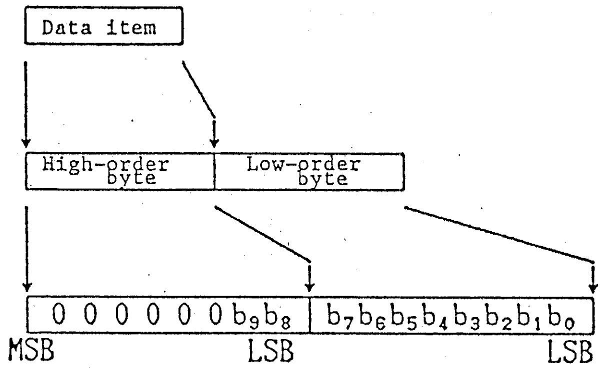


"S" represents a sign.
Data = $2^{14} \times b_{14} + 2^{13} \times b_{13} + \text{------} + 2^{0} \times b_{0} - s \times 2^{15}$
Voltage (V) = C x data/32768

Voltage range	C (coefficient)
+30dBV	4.472×10^{1}
+20dBV	1.414×10^{1}
+10dBV	4.472
0dBV	1.414
-10dBV	4.472×10^{-1}
-20dBV	1.414×10^{-1}
-30dBV	4.472×10^{-2}
-40dBV	1.414×10^{-2}
-50dBV	4.472×10^{-3}
-60dBV	1.414×10^{-3}

(2) Histogram data

Each item of histogram data is 2 bytes long, unsigned, and transmitted high-order byte first, low-order byte second.

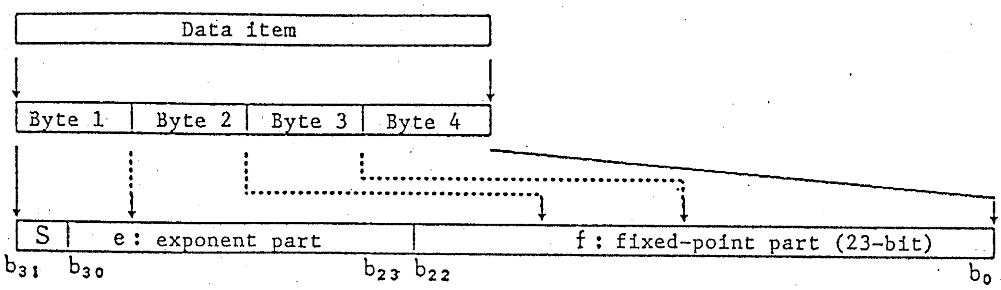


Data = $2^9 \times b_9 + 2^8 \times b_8 + 2^7 \times b_7 + \text{-------} + 2^0 \times b_0$

Probability = data/512

(3) Magnitude spectrum data

Each item of power spectrum data is 4 bytes long, represented with floating-point, and transmitted sequentially from byte 1 to byte 4.



"S" represents a sign (0 for plus, 1 for minus). 'e" represents an 8-bit-long exponent part that takes a value between 0 and 255 (exclusive). Practically, this part is treated as a bias of 127.

"f" represents a 23-bit-long fixed-point part, with a point positioned to the left of bit b_{22}. Bit b_{22} through B_0 indicate decimal places. When normalized, this part is always in the form of "1.xxx," with "1" omitted. The actual value is "1.f".

Given these values, we get:

Data = $(-1)^s \times 2^{(e-127)} \times 1.f$

where, $e = 2^7 \times b_{30} + 2^6 \times b_{29} + \text{-------} + 2^0 \times b_{23}$

$f = 2^{-1} \times b_{22} + 2^{-2} \times b_{21} + 2^{-3} \times b_{20} + \text{---} + 2^{-23} \times b_0$

Voltage range	C (coefficient)
+30dBV	1.000×10^3
+20dBV	1.000×10^2
+10dBV	1.000×10^1
0dBV	1.000×10^0
-10dBV	1.000×10^{-1}
-20dBV	1.000×10^{-2}
-30dBV	1.000×10^{-3}
-40dBV	1.000×10^{-4}
-50dBV	1.000×10^{-5}
-60dBV	1.000×10^{-6}

The data obtained here is normalized spectrum data, which needs to be computed as shown below if conversion to power or effective values is required.

1) Spectrum computation in units of V^2 (power)

   Spectrum (V^2) = C x data

2) Spectrum computation in units of dBV

   Spectrum (dBV) = $10 \times \log_{10}$ (C x data)

3) Spectrum computation in units of V (effective value)

   Spectrum (V) = $\sqrt{C \times data}$

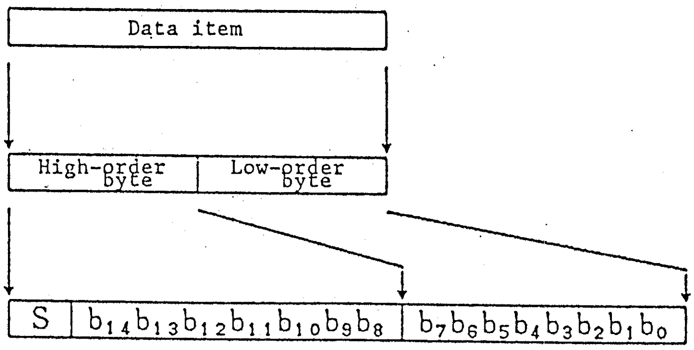
(4) Phase spectrum data

Each item of phase spectrum data is 2 bytes long, expressed in two's complement, and transmitted high-order byte first, low-order byte second.

Data = $2^{14} \times b_{14} + 2^{13} \times b_{13} + \ldots + 2^0 \times b_0 - S \times 2^{15}$

S: Sing bit

Phase = 180° x data / 32768 (degrees)


Data item
High-order byte
Low-order byte
S
b14 b13 b12 b11 b10 b9 b8
b7 b6 b5 b4 b3 b2 b1 b0

10.8 Command Lists

Explained below are the parameters that are usable with each of the commands available. Each parameter is keyed to the data transmitted by the analyzer when it is designated as talker. The format of each command list below is as follows:

- o: This command can be sent together with other command(s).
- x: This command must be sent alone.

Command name	Command function		
Parameter 1 Parameter 2 ⋮	The function executed when the parameter listed to the left is attached to the command.	The message returned when the analyzer is designated as talker immediately after.	

(Example)

VIW	Changes the domain of the displayed waveform.		o
0	Changes the current display to a spectrum display.	SPECTRUM	
1	Changes the current display to a time display.	TIME	
2	Changes the current display to a histogram display.	HISTGRAM	
?	Reads the domain of the displayed waveform.	0, 1, 2	

In a typical table like the one above, sending "VIW 0" to the FFT analyzer changes the current display to a spectrum display. Later, the analyzer returns "SPECTRUM" if designated as talker. If there is no need to read character strings such as "SPECTRUM," it is not necessary to designate the analyzer as talker. When command "VIW?" is transmitted to the analyzer, the numeral corresponding to the display domain enters the analyzer's talker buffer. Designating the analyzer as talker immediately after causes the numeral to be returned.
The meaning of each numeral corresponds to the function implemented when the numeral is operated on as a parameter. For example, if "0" is returned, it means that a spectrum display is in effect.

Additional explanations are given where, with some commands, the parameter value is different in meaning from the numeral obtained by designating the analyzer as talker.
As indicated above, the command whose list has a circle (o) symbol in its top right corner can be transmitted along with other commands. Notice that if a value read command is followed by another command, the contents of the talker buffer will be replaced by those of the subsequent command.
The command whose list has a cross (x) symbol in its top right corner must be transmitted alone.
In 10.8.1 and 10.8.2 that follow, parameters are sent and received in ASCII data. In 10.8.3, parameters are exchanged in binary data.

10.8.1 Single-Parameter Commands

Each of these commands has only one parameter that follows it.

Average domain command

AVD	Sets the domain to be averaged.	o
0 1 2 ?	Selects the spectrum domain to be averaged. Selects the time domain to be averaged. Selects the histogram domain to be averaged. Reads the domain to be averaged.	AVERAGE SPEC " TIME " HIST 0, 1, 2

* The value obtained by "AVD?" is not "n" set in "AVDn" but the value corresponding to the domain where averaging was actually carried out.

Average start command

AVG	Starts, stops, or continues averaging.	o
0 1 ?	Starts or stops averaging. Continues averaging. Reads the averaging state.	AVERAGE START/STOP AVERAGE CONTINUE 0, 1, 2

One of the following numerals is obtained by designating the analyzer as talker after transmission of the "AVG?" command.

0: Averaging terminated
1: Averaging under way
2: Averaging being suspended

Average/instant command

AVI	Selects an average or instant waveform display.	o
0 1 ?	Selects an instant waveform display. Selects an average waveform display. Reads the average/instant state of the waveform display.	INSTANT AVERAGE 0, 1

Averaging mode command

AVM	Sets the averaging mode.	o
0 1 2 ?	Performs averaging with SUMN. Performs averaging with PEAK. Performs averaging with EXP. Reads the current averaging mode.	NORMAL PEAK EXP 0, 1, 2

* The value obtained by "AVM?" is not "n" set in "AVMn" but the value corresponding to the mode in which averaging was actually carried out.

Averaging count command

AVN	Sets the averaging count.	o
0	Sets the averaging count to 2.	AVERAGE NUMBER 0
1	" 4.	" 1
2	" 8.	" 2
3	" 16.	" 3
4	" 32.	" 4
5	" 64.	" 5
6	" 128.	" 6
7	" 256.	" 7
8	" 512.	" 8
9	" 1024.	" 9
10	" 2048.	" 10
11	" 4096.	" 11
12	" 8192.	" 12
?	Reads the averaging count.	0 - 12

* The value obtained by "AVN?" is not "n" set in "AVNn" but the value corresponding to the actual averaging count.

Averaging restart command

ARS	Specifies restarting of averaging.	o
0 1 ?	Restart Off (Disables restarting of averaging.) Restart On (Enables restarting of averaging.) Reads the ARS setting.	AV RESTART OFF AV RESTART ON 0, 1

Buzzer command

CAV	Turns on or off the buzzer.	o
0 1 ?	Turns the buzzer off. Turns the buzzer on. Reads the buzzer setting.	BUZZER OFF BUZZER ON 0, 1

Comparator average command

CAV	Selects an average or instant waveform display for comparator execution.	o
0 1 ?	Selects an instant waveform display for the comparator. Selects an average waveform display for the comparator. Reads the comparator's waveform display.	COMPINST COMPAVRG 0, 1

Comparator clock command

CCK	Sets an internal or external A/D sampling clock for comparator execution.	o
0 1 ?	Sets an internal A/D sampling clock. Sets an external A/D sampling clock. Reads the A/D sampling clock.	INTERNAL EXTERNAL 0, 1

Comparator domain command

CDM	Sets the waveform domain for comparator execution.	o
0 1 2 ?	Sets the spectrum domain. Sets the time domain. Sets the histogram domain. Reads the domain.	COMP SPEC COMP TIME COMP HIST 0, 1, 2

Cursor display mode command

CDP	Sets the cursor format.	o
0 1 ?	Sets the cursor format to mode 0. Sets the cursor format to mode 1. Reads the cursor format.	CURSOR DISPLAY 0 CURSOR DISPLAY 1 0, 1

Comparator frequency command

CFR	Sets the frequency range for comparator execution.	o
0	Sets the frequency range to 1 Hz.	COMP FREQ 0
1	" 2 Hz.	" 1
2	" 5 Hz.	" 2
3	" 10 Hz.	" 3
4	" 20 Hz.	" 4
5	" 50 Hz.	" 5
6	" 100 Hz.	" 6
7	" 200 Hz.	" 7
8	" 500 Hz.	" 8
9	" 1 kHz.	" 9
10	" 2 kHz.	" 10
11	" 5 kHz.	" 11
12	" 10 kHz.	" 12
13	" 20 khz.	" 13
?	Reads the frequency range.	0 - 13

Clock command

CLK	Sets the A/D sampling clock.	o
0 1 ?	Sets an internal clock. Sets an external clock. Reads the clock setting.	INTERNAL EXTERNAL 0, 1

Comparator mode command

CMD	Sets the comparator execution mode.	o
0 1 ?	Sets a free execution mode. Sets a single execution mode. Reads the execution mode.	FREE SINGLE 0, 1

Comparator marker command

CMK	Turns on or off the comparator marker.	o
0 1 ?	Turns off the marker. Turns on the marker. Reads the marker setting.	MARKER OFF MARKER ON 0, 1

Comparator command

CMP	Turns on or off the comparator.	o
0 1 ?	Turns the comparator off. Turns the comparator on. Reads the comparator's on/off state.	COMP OFF COMP ON 0, 1

* If the screen is altered by a command that was sent following "CMP1", send "CMP1" again. During comparator execution, do not send commands other than "CPM", "CPS", "CRS" and "CRT". In other words, set up all conditions of measurement before sending "CMP1".

Coupling command

CPL	Sets the input coupling (equivalent to AC/DC key).	o
0 1 ?	Sets the input for AC coupling. Sets the input for DC coupling. Reads the input coupling.	AC COUPLE DC COUPLE 0, 1

Comparator start command

CPS	Starts the comparator.	o
1 or @	"	COMP START

Copy command (Effective only with printer option provided)

CPY	Starts copy operation.	o
1 or @	"	COPY START

Compared result command

CRS	Reads the result of comparator execution (individual).	o
?	"	See below.

$$A0\sqcup\begin{Bmatrix}\text{OFF}\\\text{GO}\\\text{NG}\end{Bmatrix}\sqcup A1\sqcup\begin{Bmatrix}\text{OFF}\\\text{GO}\\\text{NG}\end{Bmatrix}\text{ -------- } A9\sqcup\begin{Bmatrix}\text{OFF}\\\text{GO}\\\text{NG}\end{Bmatrix}$$

Braces { } indicate that one of the items inside is transmitted. After power-up, "GO" persists until the first compared result is output.

Overall compared result command

CRT	Reads the result of comparator execution (overall).	o
?	"	0, 1, 2

0: Comparator not executed 1: NOGO 2: GO

Cursor/frame command

CSF	Sets the cursor or frame mode.	o
0 1 ?	Sets the frame mode. Sets the cursor mode. Reads the cursor/frame setting.	FRAME CURSOR 0, 1

Comparator input range command

CSN	Sets the input range for comparator execution.	o
0	Sets the input range to -60 dBV.	COMP SENSE 0
1	Sets the input range to -50 dBV.	COMP SENSE 1
2	Sets the input range to -40 dBV.	COMP SENSE 2
3	Sets the input range to -30 dBV.	COMP SENSE 3
4	Sets the input range to -20 dBV.	COMP SENSE 4
5	Sets the input range to -10 dBV.	COMP SENSE 5
6	Sets the input range to 0 dBV.	COMP SENSE 6
7	Sets the input range to +10 dBV.	COMP SENSE 7
8	Sets the input range to +20 dBV.	COMP SENSE 8
9	Sets the input range to +30 dBV.	COMP SENSE 9
?	Reads the input range.	0 - 9

Cursor command

CSR	Moves the cursor.	o
0 ↓ 200	Positions the cursor to location 0 (leftmost) on the screen. ↓ Positions the cursor to location 200 (rightmost) on the screen.	CURSOR 0 ↓ CURSOR 200
?	Reads the cursor position.	0 - 200

Comparator status command

CST	Reads the comparator operation status.	o
?		See below.

Below are the values obtained by designating the analyzer as talker following transmission of the "CST?" command.

0 : OFF
1 : STAND BY
2 : BUSY
3 : END

Counter print command (effective only with printer option provided)

CTP	Specifies whether or not to have the counter value printed by the printer.	o
0	Suppresses printing of the counter value.	COUNT PRINT OFF
1	Causes the counter value to be printed.	COUNT PRINT ON
?	Reads the setting of the printing status.	0, 1

Comparator axis log/linear command

CVL	Specifies whether the vertical axis is to be logarithmic or linear for comparator execution.	o
0 1 ?	Makes the vertical axis linear. Makes the vertical axis logarithmic. Reads the vertical axis setting.	LINEAR LOG 0, 1

Comparator voltage command

CVR	Specifies whether the vertical axis of a spectrum is to represent amplitude or effective values for comparator execution.	o
0 1 ?	Makes the vertical axis represent effective values. Makes the vertical axis represent amplitude values. Reads the vertical axis setting.	COMP VRMS COMP V 0, 1

Comparator voltage command

CVV	Sets the vertical axis of a spectrum to V or V^2 for comparator execution.	o
0 1 ?	Sets the vertical axis to V. Sets the vertical axis to V^2. Reads the vertical axis setting.	COMP V COMP VV 0, 1

Delta cursor command

DCS	Moves the delta cursor.	o
0 ↓ 200 ?	Positions the delta cursor to location 0 (leftmost) on the screen. ↓ Positions the delta cursor to location 200 (rightmost) on the screen. Reads the delta cursor position.	DELTA 0 ↓ DELTA 200 0 - 200

Delta cursor on/off command

DLT	Turns the delta cursor on or off.	o
0	Turns the delta cursor off.	DELTA OFF
1	Turns the delta cursor on.	DELTA ON
?	Reads the on/off state of the delta cursor.	0, 1

Date print command (effective only with printer option provided)

DTP	Turns the printing of dates on or off.	o
0	Suppresses date printing.	DATE PRINT OFF
1	Performs date printing.	DATE PRINT ON
?	Reads the date print on/off state.	0, 1

Date setting command (effective only with printer option provided)

DTS	Sets a date on the internal clock.	o
10100	Sets January 1, 2000.	DATE 10100
↓		
123199	Sets December 31, 1999.	DATE 123199
?	Reads the current date.	10100 - 123199

A date is given as a 5- or 6-digit number, digits 10^5 and 10^4 representing a month, 10^3 and 10^2 representing a day, and 10^1 and 10^0 representing a year.

    0 0   0 0   0 0
    Month Day   Year

EU command (logarithmic)

EUG	Sets the EU value for a spectrum whose vertical axis is logarithmic in display.	o
-9999	0 dBEU = -999.9	LOG EU = -9999
↓	↓	↓
9999	0 dBEU = 999.9	LOG EU = 9999
?	Reads the EU value.	-9999 - 9999

The EU value is set as a signed 4-digit integer. The value transmitted is 10 times the actual set value.
Example: When setting 0 dBEU = -12.3, transmit "EUG-123".

EU command (linear)

EUL	Sets the EU value for a spectrum whose vertical axis is linear in display.	o
-9999 ↓ 9999	1V = 999E-9 ↓ 1V = 999E+9	LINEU = -9999 ↓ ↓ LINEU = 9999
?	Reads the EU value.	-9999 - 9999

The EU value is set as a signed 4-digit integer. The format of the value is slightly different from that of the actual set value.

Format set by panel keys: +123-4
Integer to be set: ±1234
Example: When setting 1EU = 1230, transmit "EUL 1231",
since 1230 → +123+1 → +1231 = "EUL 1231"

EU set command (valid when optional expansion memory is installed in the system.)

EUS	Sets the cursor readout value or peak value as an EU value.	o
1 or @	"	EU SET

Differentiation/Integration command

FDI	Performs differentiation or integration operations on spectrums.	o
0	Turns off operations.	DI OFF
1	Performs differentiation operation.	DIFFERENTIAL
2	Performs double differentiation operation.	D DIFFERENTIAL
3	Performs integration operation.	INTEGRAL
4	Performs double integration operation.	I INTEGRAL
?	Reads the differentiation/integration setting.	0 - 4

Feed command (effective only with printer option provided)

FED	Feeds printer paper.	o
1 ↓ 99	Feeds printer paper by 1 line. ↓ Feeds printer paper by 99 lines.	FEED 1 ↓ FEED 99

Filter command

FLT	Turns the filter on or off.	o
0	Turns the filter off.	FILTER OFF
1	Turns the filter on.	FILTER ON
?	Reads the filter setting.	0, 1

Function command

FPM	Sets the type of screen computation.	o
0 1 2 ?	Turns computation off. Performs add (+) operation. Performs subtract (-) operation. Reads the type of computation.	FUNCTION OFF FUNCTION PLUS FUNCTION MINUS 0, 1, 2

Frame command

FRM	Sets the location at which to start time waveform display.	o
0 ↓ 487 ?	Starts the display at location 0 of time data. ↓ Starts the display at location 487 of time data. Reads the display starting location.	FRAME 0 ↓ FRAME 487 0 - 487

The frame value varies depending on the scale factor for the time axis.

1x: Frame stationary
2x: 0 - 112
4x: 0 - 312
8x: 0 - 412
16x: 0 - 462
32x: 0 - 487

Frequency command

FRQ	Sets the frequency range.	o
0 1 2 3 4 5 6 7 8 9 10 11 12 13 ?	Sets the frequency range to 1 Hz. Sets the frequency range to 2 Hz. Sets the frequency range to 5 Hz. Sets the frequency range to 10 Hz. Sets the frequency range to 20 Hz. Sets the frequency range to 50 Hz. Sets the frequency range to 100 Hz. Sets the frequency range to 200 Hz. Sets the frequency range to 500 Hz. Sets the frequency range to 1 kHz. Sets the frequency range to 2 kHz. Sets the frequency range to 5 kHz. Sets the frequency range to 10 kHz. Sets the frequency range to 20 kHz. Reads the frequency range.	FREQUENCY RANGE 0 FREQUENCY RANGE 1 FREQUENCY RANGE 2 FREQUENCY RANGE 3 FREQUENCY RANGE 4 FREQUENCY RANGE 5 FREQUENCY RANGE 6 FREQUENCY RANGE 7 FREQUENCY RANGE 8 FREQUENCY RANGE 9 FREQUENCY RANGE 10 FREQUENCY RANGE 11 FREQUENCY RANGE 12 FREQUENCY RANGE 13 0 - 13

Measurement speed command (keyed to the MODE item in the WIND menu)

FST	Sets the measurement speed.		o
0 1 ?	Sets the slow mode. Sets the fast mode. Reads the measurement speed.	SLOW MODE FAST MODE 0, 1	

Frequency axis unit command

FUT	Sets the unit for use on the frequency axis.		o
0 1 2 ?	Sets the unit to Hz. Sets the unit to CPM. Sets the unit to ORD. Reads the unit.	UNIT Hz UNIT CPM UNIT ORD 0, 1, 2	

Gain command

GIN	Sets the scale factor for the vertical axis.		o
0 ↓ 16 ?	Sets the scale factor to 1x. Sets the scale factor to 65536x. Reads the scale factor.	GAIN 0 GAIN 16 0 - 16	

The scale factor varies depending on waveform type.

	Scale factor	Parameter range
Time waveform	: 1x - 16x	0 - 4
Histogram waveform	: 1x - 16x	0 - 4
Spectrum (phase) waveform	: 1x - 8x	0 - 3
Specturm (linear magnitude) waveform	: 1x - 65536x	0 - 16
Spectrum (logarithmic magnitude) waveform	: 80 dB - 16 dB	0 - 8

Notice that the GIN command is not executed while the comparator's area marker is being displayed.

Ground command

GND	Connects the input to ground.		o
0 1 ?	Connects the input to signals. Connects the input to ground. Reads the input state.	SIGNAL GROUND 0, 1	

Graticule command

GRT	Turns the graticule on or off.		o
0 1 ?	Turns the graticule off. Turns the graticule on. Reads the graticule setting.	GRATICULE OFF GRATICULE ON 0, 1	

Harmonics command

HRM	Turns harmonics on or off.	o
0 1 ?	Turns harmonics off. Turns harmonics on. Reads the harmonics setting.	HARMONICS OFF HARMONICS ON 0, 1

Menu command

MEN	Moves the menu cursor.	o
0	Positions the cursor to AVRG.	MENU 0
1	Positions the cursor to TRIG.	MENU 1
2	Positions the cursor to SCAL.	MENU 2
3	Positions the cursor to FUNC.	MENU 3
4	Positions the cursor to COMP.	MENU 4
5	Positions the cursor to WIND.	MENU 5
6	Positions the cursor to OPTN.	MENU 6
7	Positions the cursor to SENS.	MENU 7
8	Positions the cursor to FREQ.	MENU 8
?	Reads the menu cursor position.	0 - 8

Magnitude/phase command

MGP	Selects either a magnitude spectrum display or a phase spectrum display.	o
0 1 ?	Displays magnitude spectrums. Displays phase spectrums. Reads the magnitude/phase setting.	MAGNITUDE PHASE 0, 1

Memory recall command

MRC	Recalls waveforms from memory.	o
0 ↓ 40	Recalls data from memory No. 0. ↓ Recalls data from memory No. 40.	MEMORY RECALL 0 ↓ MEMORY RECALL 40

Where the optional expansion memory is not provided, only "MRCO" is effective.

Memory store command

MST	Stores waveforms into memory.	o
0 ↓ 40	Stores data in memory No. 0. ↓ Stores data in memory No. 40.	MEMORY STORE 0 ↓ MEMORY STORE 0

Where the optional expansion memory is not provided, only "MSTO" is effective.

Overall command

OVA	Sets overall computation.	o
0 1 2 ?	Turns off overall computation. Turns on overall computation. Sets partial overall computation. Reads the setting of overall computation.	OVERALL OFF OVERALL ON OVERALL PARTIAL 0, 1, 2

Print count command (effective only with printer option provided)

PCT	Sets the print counter value.	o
0 ↓ 9999 ?	Sets 0 on the counter. ↓ Sets 9999 on the counter. Reads the counter value.	PRINT COUNT 0 ↓ PRINT COUNT 9999 0 - 9999

Position/gain command

PGS	Sets the function of the ▲▼ keys in the DISPLAY section to either GAIN or POSITION.	o
0 1 ?	Sets the key function to GAIN. Sets the key function to POSITION. Reads the GAIN/POSITION setting.	GAIN POSITION 0, 1

Position command

POS	Moves the waveform position.	o
-80 ↓ 128 ?	Reads the waveform position.	POSITION -80 ↓ POSITION 128 -80 - 128

The position value varies depending on waveform type.

	Range	Increments of movement
Time waveform	-64 - 64	1/64 of increment with scale factor 1x
Spectrum (phase) F waveform	-60 - 40	1/40 of increment with scale factor 1x
Spectrum (linear magnitude) waveform	0 - 128	1/128 of increment with scale factor 1x
Spectrum (logarithmic magnitude) waveform	-80 - 80	In increments of 10 dB, 5 dB or 2 dB

Panel recall command

PRC	Recalls the stored panel setting.		o
0 ↓ 9	Recalls data from panel memory No. 0 ↓ Recalls data from panel memory No. 9	PANEL RECALL 0 ↓ PANEL RECALL 9	

Where the optional expansion memory is not installed, memories No. 1 to No. 4 are effective.

Print direction command (effective only with optional printer provided)

PRD	Sets the direction of printing.		o
0 1 ?	Performs printing bi-directionally. Performs printing unidirectionally. Reads the direction of printing.	BIDIRECTION SINGLE DIRECTION 0, 1	

Print event command (effective only with optional printer provided)

PRE	Sets the print event.		o
0 1 2 3 4 ?	Sets the event to OFF. Sets the event to COMP. Sets the event to COMPNG. Sets the event to AVRG. Sets the event to SMPL. Reads the event setting.	PRINT EVENT OFF PRINT EVENT COMP PRINT EVENT COMPNG PRINT EVENT AVERAGE PRINT EVENT SAMPLE 0 - 4	

Print mode command (effective only with optional printer provided)

PRM	Sets the print mode.		o
0 1 2 ?	Prints hard copy. Prints a parameter list. Prints hard copy and a parameter list. Reads the mode setting.	HARDCOPY PARAMETER LIST HARD + PARAMETER 0, 1, 2	

Panel store command

PST	Stores the current panel setting.		o
0 ↓ 9	Stores the panel setting in panel memory No. 0. ↓ Stores the panel setting in panel memory No. 9.	PANEL STORE 0 ↓ PANEL STORE 9	

Where the optional expansion memory is not installed, memories No. 1 to No. 4 are effective.

Read average count command

RAC	Reads the averaging count of averaged data.	o
?		0 - 12

0: Twice
1: 4 times
2: 8 times
3: 16 times
4: 32 times
5: 64 times
6: 128 times
7: 256 times
8: 512 times
9: 1024 times
10: 2048 times
11: 4096 times
12: 8192 times

Read average domain command

RAD	Reads the domain of averaged data.	o
?		0, 1, 2

0: Spectrum domain data
1: Time domain data
2: Histogram domain data

Read average frequency command

RAF	Reads the frequency range of averaged data.	o
?		0 - 13

0: 1 Hz
1: 2 Hz
2: 5 Hz
3: 10 Hz
4: 20 Hz
5: 50 Hz
6: 100 Hz
7: 200 Hz
8: 500 Hz
9: 1 kHz
10: 2 kHz
11: 5 kHz
12: 10 kHz
13: 20 kHz

Read average mode command

RAM	Reads the mode of averaged data.	o
?		0, 1, 2

0: SUMN
1: PEAK
2: EXP

Read average sense command

RAS	Reads the sense range of averaged data.	o
?		0 - 9

0:	-60 dBV	5:	-10 dBV
1:	-50 dBV	6:	0 dBV
2:	-40 dBV	7:	+10 dBV
3:	-30 dBV	8:	+20 dBV
4:	-20 dBV	9:	+30 dBV

Read cursor command

RCS	Reads cursor values and computed values.	o
0 1 2 3	Reads the upper cursor value. Reads the lower cursor value. Reads the overall computed value. Harmonics.	Refer to (3) in 7.2.

Read ID command

RID	Causes character string "FFT ANALYZER" to be loaded.	o
?	Causes character string "FFT ANALYZER" to be loaded.	FFT ANALYZER

Read option command

ROP	Causes the character string identifying an option to be loaded.	o
?	Causes the character string identifying an option to be loaded.	See below.

GP-IB: GP-IB Installed
MEMORY: Expansion memory installed
PRINTER: Printer installed
GP-IB MEMORY PRINTER: All three options installed

Scaling command

SCL	Sets the scale.	o
0 1 2 3 ?	Turns the scale off. Performs SCL operation. Performs /Hz operation. Performs SL/Hz operation. Reads the scale setting.	SCALE OFF SCALE EU SCALE PHZ SCALE EUPHZ 0, 1, 2, 3

Sense range command

SNS	Sets the input sense range.	o
0	Sets the input sense range to -60 dBV.	SENSE RANGE 0
1	Sets the input sense range to -50 dBV.	SENSE RANGE 1
2	Sets the input sense range to -40 dBV.	SENSE RANGE 2
3	Sets the input sense range to -30 dBV.	SENSE RANGE 3
4	Sets the input sense range to -20 dBV.	SENSE RANGE 4
5	Sets the input sense range to -10 dBV.	SENSE RANGE 5
6	Sets the input sense range to 0 dBV.	SENSE RANGE 6
7	Sets the input sense range to +10 dBV.	SENSE RANGE 7
8	Sets the input sense range to +20 dBV.	SENSE RANGE 8
9	Sets the input sense range to +30 dBV.	SENSE RANGE 9
?	Reads the input sense range.	0 - 9

SRQ mask command

SQM	Sets the SRQ mask.	o
0	Sets the mask value to 0.	SRQ MASK VALUE 0
31	Sets the mask value to 31.	SRQ MASK VALUE 31
?	Reads the mask value.	0 - 31

The contents of the SRQ mask register are set after conversion to decimal notation.

Trigger command

TRG	Sets the trigger mode.	o
0	Sets the free-run mode.	FREE RUN
1	Sets the hold mode.	HOLD
2	Sets the arm mode.	ARM
3	Sets the auto arm mode.	AUTO ARM
?	Reads the trigger mode.	0, 1, 2, 3

Time expand command

TEX	Expands the time axis.	o
0	Expands the axis by a factor of 1.	EXPAND 1 x
1	Expands the axis by a factor of 2.	EXPAND 2 x
2	Expands the axis by a factor of 4.	EXPAND 4 x
3	Expands the axis by a factor of 8.	EXPAND 8 x
4	Expands the axis by a factor of 16.	EXPAND 16 x
5	Expands the axis by a factor of 32.	EXPAND 32 x
?	Reads the scale factor.	0 - 5

Trigger slope command

TGE	Sets the trigger slope.		o
0	Activates the trigger at a leading edge.	SLOPE UP	
1	Activates the trigger at a trailing edge.	SLOPE DOWN	
?	Reads the trigger slope setting.	0, 1	

Trigger level command

TGL	Sets the trigger level.		o
0	Sets the trigger level to +7/8 F.S.	TRIGGER LEVEL 0	
↓	↓	↓	
14	Sets the trigger level to -7/8 F.S.	TRIGGER LEVEL 14	
?	Reads the trigger level setting.	0 - 14	

Trigger position command

TGP	Sets the trigger position.		o
0	Sets the trigger position to PRE 512.	TRIGGER POSITION 0	
↓	↓	↓	
1024	Sets the trigger position to PST 512.	TRIGGER POSITION 1024	
	Reads the trigger position setting.	0 - 1024	

Trigger source command

TGS	Sets the trigger source.		o
0	Selects the internal trigger source.	INTERNAL TRIGGER	
1	Selects an external trigger source.	EXTERNAL TRIGGER	
?	Reads the trigger source setting.	0, 1	

Harmonics select command

THS	Selects the type of harmonics computation.		o
0	Performs THD computation.	THD	
1	Performs THP computation.	THP	
2	Performs THD computation and displays a listing of results.	HDL	
3	Performs THP computation and displays a listing of results.	HPL	
?	Reads the harmonics computation setting.	0, 1, 2, 3	

Time set command (effective only with optional printer installed)

TMS	Sets the time on the internal clock.	o
0	Sets "0:0:0."	TIME 000000
↓	↓	↓
235959	Sets "23:59:59."	TIME 235959
?	Reads the current time.	0 - 235959

The time is given as a 6-digit number, digits 10^5 and 10^4 representing hours, 10^3 and 10^2 representing minutes, and 10^1 and 10^0 representing seconds.

0 0	0 0	0 0
Hours	Minutes	Seconds

Time print command (effective only with optional printer installed)

TPR	Turns printing of the time on or off.	o
0	Suppresses time printing.	TIME PRINT OFF
1	Prints the time.	TIME PRINT ON
?	Reads the time print setting.	0, 1

Test command

TST	Feeds a test signal to the input circuitry (equivalent to TEST key operation).	o
0	Feeds measurement signals to the input circuitry.	TEST OFF
1	Feeds a test signal to the input circuitry.	TEST ON
?	Reads the input setting.	0, 1

View command

VIW	Sets the domain for the waveform being displayed.	o
0	Sets the spectrum domain for display.	SPECTRUM
1	Sets the time domain for display.	TIME
2	Sets the histogram domain for display.	HISTGRAM
?	Reads the domain of the waveform being displayed.	0, 1, 2

Effective voltage command

VRM	Specifies whether or not to indicate voltages in effective values on the vertical axis of spectrums.		o
0	Indicates effective values.	VRMS	
1	Indicates amplitude values.	V	
?	Reads the voltage indication setting.	0, 1	

Square command

VSQ	Specifies whether voltages on the vertical axis of spectrums are to be indicated in V or V^2.		o
0	Indicates voltages in V.	V	
1	Indicates voltages in V^2.	VV	
?	Reads the voltage indication setting.	0, 1	

Window command

WND	Sets the window type.		o
0	Sets the hanning window.	HANNING	
1	Sets the rectangular window.	RECTANGULAR	
2	Sets the flat-top window.	FLAT TOP	
?	Reads the window setting.	0, 1, 2	

Horizontal axis logarithmic command

XLG	Makes the frequency axis for spectrums logarithmic or linear (equivalent to operating X-LOG key).		o
0	Makes the axis linear.	LINEAR	
1	Makes the axis logarithmic.	LOG	
?	Reads the frequency axis setting.	0, 1	

Vertical axis logarithmic command

YLG	Makes the voltage axis for spectrums logarithmic or linear (equivalent to operating Y-LOG key).		o
0	Makes the axis linear.	LINEAR	
1	Makes the axis logarithmic.	LOG	
?	Reads the voltage axis setting.	0, 1	

10.8.2 Multiple Parameter Commands

The commands discussed below each have multiple parameters.

Memory ID command (effective only with expansion memory option provided)

MID	2nd parameter	Sets the memory ID number.	o
0	0	Sets to 0 the ID of the memory whose number is in the 2nd parameter.	MEMORY ID 0
↓	↓		
9999	40	Sets to 9999 the ID of the memory whose number is in the 2nd parameter.	MEMORY ID 9999
?		Reads the ID of the memory whose number is in the 2nd parameter.	0 - 9999

Example: If command "MID 1234 5" is sent, the ID of memory No. 5 becomes 1234.

Memory protect command
(effective only with expansion memory option provided)

MPT	2nd parameter	Sets memory protection.	o
0	0	Turns off memory protection on the memory whose number is in the 2nd parameter.	MEMORY 0
1	↓	Turns on memory protection on the memory whose number is in the 2nd parameter.	PROTECT 1
?	40	Reads the status of memory protection on the memory whose number is in the 2nd parameter.	0, 1

Example: If command "MPT 1 23" is sent, memory protection is effected on memory No. 23.

Area command

ARA	2nd parameter	3rd parameter	4th parameter	5th parameter	6th parameter	7th Parameter	x
0 ↓ 9	0 1	0 1 2	0 ↓ 200	0 ↓ 200	0 ↓ 128	0 ↓ 128	

The area (ARA) command is used to set the comparator area. Be sure to transmit the area command before transmitting the "CMP1" command.

The first parameter specifies the area number ($0 \leqq$ 1st parameter $\leqq 9$).

The second parameter specifies whether or not to turn on the area specified in the first parameter.

0 : OFF
1 : ON

The third parameter specifies how to compare data in the comparator area specified in the first parameter.

0 : PEAK
1 : LEVEL
2 : Poa (effective only with spectrums)

The fourth parameter specifies the value of the waveform display screen address at the leftmost position of the comparator area. The value varies depending on the waveform to be compared.

Time waveform : $0 \leqq$ 4th parameter $\leqq 168$
Spectrum waveform : $0 \leqq$ 4th parameter $\leqq 198$
Histogram waveform : $36 \leqq$ 4th parameter $\leqq 162$

Notice that the fourth parameter must be smaller than the fifth parameter minus 1.

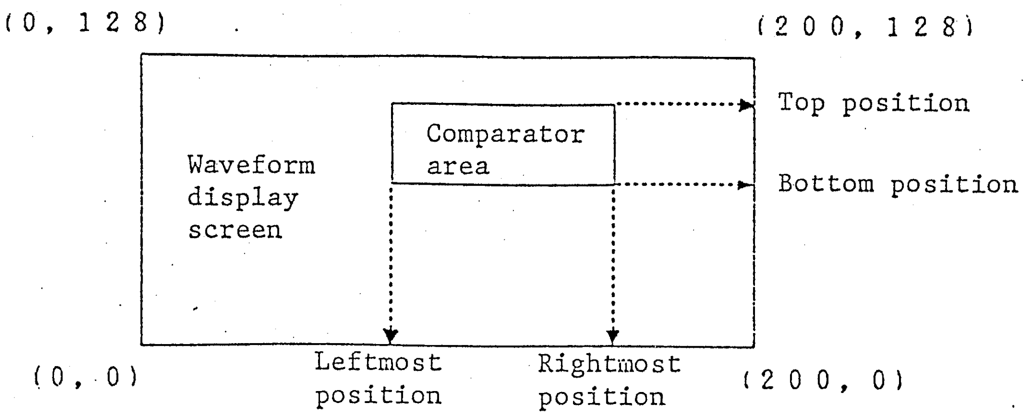
The fifth parameter specifies the value of the waveform display screen address at the rightmost position of the comparator area. The value varies depending on the waveform to be compared.

Time waveform : $2 \leqq$ 5th parameter $\leqq 170$
Spectrum waveform : $2 \leqq$ 5th parameter $\leqq 200$
Histogram waveform : $38 \leqq$ 5th parameter $\leqq 164$

Again notice that the fourth parameter must be smaller than the fifth parameter minus 1.

The sixth parameter specifies the value of the waveform display screen address at the bottom position of the comparator area. Notice that $0 \leqq$ 6th parameter $\leqq 126$, and that 6th parameter < 7th parameter - 1.

The seventh parameter specifies the value of the waveform display screen address at the top position of the comparator area. Notice that $2 \leqq$ 7th parameter $\leqq 128$, and that 6th parameter < 7th parameter - 1.



* Having data returned by designating the analyzer as talker after area command transmission, and reading the set data. When the analyzer is designated as talker after transmission of command "ARA n_1 n_2 n_3 n_4 n_5 n_6 n_7," the analyzer returns "AREA n_1 $\begin{Bmatrix} \text{OFF} \\ \text{ON} \end{Bmatrix}$ $\begin{Bmatrix} \text{PEAK} \\ \text{LEVEL} \\ \text{Poa} \end{Bmatrix}$ n_4 n_5 n_6 n_7."

Braces { } indicate that one of the items inside is transmitted. If it is desired to read the parameter in the area established, designate the analyzer as talker after sending the "ARn?" command to it. "n" is an area number ranging from 0 to 9.

Example: To read the parameter in area 3, send "AR3?."

10.8.3 Commands with Binary Parameters

(1) Commands for setting binary data in FFT analyzer

Binary time command

BTM	Sets binary time data in the FFT analyzer	x
Refer to (4) in 7.1.3.	TIME DATA READ (sets binary time data in the FFT analyzer)	

Example: "BTM#IB_1B_2 ----- B_{1024}" (Bn is one-byte data.)

The FFT analyzer must be placed in a hold state before it can accept this command. Binary data is fixed in length. Bn (high-order byte) and Bn+1 (low-order byte) constitute a 16-bit time data item, where "n" is an odd number. This command is used to transmit to the analyzer the time data involving externally computed or measured values. On receipt of the data, the analyzer displays its waveforms or converts it to spectrums.

Binary memory data command

BMD	Sets binary memory data in the FFT analyzer.	x
Refer to (4) in 7.1.3.	MEMORY DATA READ (sets binary memory data in the FFT analyzer)	

Example: "BMD#IB_1B_2-----B_{1446}" (Bn is one-byte data.)

Binary data is fixed in length. This command is used to read memory data from external files (stored there by MDD command) and put it back in the analyzer's memory.

Binary panel data command

BPL	Sets binary panel data in the FFT analyzer.	x
Refer to (4) in 7.1.3.	PANEL DATA READ (sets binary panel data in the FFT analyzer)	

Example: "BPL#IB_1N_2-----B_{422}" (Bn is one-byte data.)

Binary data is fixed in length. This command is used to read panel memory data from external files (stored there by PLD command) and put it back in the analyzer's panel memory.

(2) Commands for having FFT analyzer transmit binary data

Memory data command

MDD	Transmits memory data.	x
0 ↓ 40	Transmits data of memory No. 0. ↓ Transmits data of memory No. 40.	Refer to 7.2, (4), 3).

Where the optional expansion memory is not provided, only parameter 0 is effective.

Panel data dump command

PLD	Transmits panel data.	x
0 ↓ 9	Transmits data of panel No. 0. ↓ Transmits data of panel No. 9.	Refer to 7.2, (4), 2).

Where the optional expansion memory is not provided, only parameters 1 - 4 are effective.

Waveform data dump command

WDD	Transmits the data whose waveform is being desplayed on the screen.	x
?	Transmits the data whose waveform is being displayed on the screen.	Refer to 7.2, (4), 1).

Harmonics Dump command

HML	Sends frequencies and levels of the fundamental and harmonic waves.	x
?	Sends frequencies and levels of the fundamental and harmonic waves.	

This command is valid when the harmonic cursor is displayed in the Magspectrum display or when a Harmonic List is displayed.

10.8.4 Commands for Three-Dimensional Display

These commands are valid when an optional extension memory is mounted.

Enable 3D command

E3D	Enables or disables three-dimensional display.		o
0	Disables three-dimensional display.	3-D DISABLE	
1	Enables three-dimensional display.	3-D ENABLE	
?	Reads the E3D setting.	0,1	

Start 3D Display command

D3S	Starts or stops three-dimensional display.		o
0	Stops three-dimensional display.	3-D STOP	
1	Starts three-dimensional display.	3-D START	
?	Reads the D3S setting.	0,1	

3D Method command

D3M	Sets MEM, VIEW, or AVRG.		o
0	Sets VIEW.	VIEW 3-D	
1	Sets MEM.	MEMORY 3-D	
2	Sets AVRG.	AVERAGE 3-D	
?	Reads the D3M setting.	0,1,2	

Line command

D3L	Sets the line pattern to be displayed.		o
0	Displays line pattern 1.	LINE NO 1	
1	Displays line pattern 2.	LINE NO 2	
↓	↓	↓	
15	Displays line pattern 16.	LINE NO 16	
?	Reads the D3L setting.	1 - 16	

Memory Position command

D3P	Sets the start memory number.	o
0 1 ↓ 32 ?	Sets memory number 0. Sets memory number 1. ↓ Sets memory number 32. Reads the memory number specified.	MEMORY POSITION 0 MEMORY POSITION 1 ↓ MEMORY POSITION 32 0 - 32

Angle command

D3A	Sets the angle type.	o
0 1 2 3 4 ?	Sets angle type LOW2. Sets angle type LOW1. Sets angle type MID. Sets angle type HI1. Sets angle type HI2. Reads the D3A setting.	LOW 2 ANGLE LOW 1 ANGLE MID ANGLE HIGH 1 ANGLE HIGH 2 ANGLE 0,1,2,3,4

10.8.5 Zooming Commands

These commands are valid when an optional expansion memory is mounted.

Enable Zooming command

EZM	Enables or disables zooming.	o
0 1 2 3 4 5 ?	Disables zooming. Enables zooming of up to magnification of x2. Enables zooming of up to magnification of x4. Enables zooming of up to magnification of x8. Enables zooming of up to magnification of x16. Enables zooming of up to magnification of x32. Reads the EZM setting.	ZOOM DISABLE ZOOM MAX x2 ZOOM MAX x4 ZOOM MAX x8 ZOOM MAX x16 ZOOM MAX x32 0,1,2,3,4,5

Start Zooming command

ZMS	Starts or stops zooming.	o
0	Stops zooming.	ZOOM STOP
1	Starts zooming.	ZOOM START
?	Reads the ZMS setting.	0,1

Zoom Magnification command

ZMG	Sets the zooming magnification	o
0	Magnification x2	ZOOM x2
1	Magnification x4	ZOOM x4
2	Magnification x8	ZOOM x8
3	Magnification x16	ZOOM x16
4	Magnification x32	ZOOM x32
?	Reads the ZMG setting.	0,1,2,3,4

Zoom Center Frequency command

ZMC	Sets the zoom center frequency during execution of zooming	o
4	Sets the zoom center frequency on line 4.	ZOOM CENTER 4
5	Sets the zoom center frequency on line 5.	ZOOM CENTER 5
↓	↓	↓
195	Sets the zoom center frequency on line 195.	ZOOM CENTER 195
196	Sets the zoom center frequency on line 196.	ZOOM CENTER 196
?	Reads the ZMC setting.	4 - 196

This command sets the zoom center frequency in the range of non-zooming frequency.
The center frequency range depends upon the zooming magnification.

Magnification	Center frequency position (range)
2	50 - 150
4	25 - 175
8	13 - 187
16	7 - 193
32	4 - 196

Frame Number command

ZTM	Sets the time frame number	o
0	Sets time frame number 0.	ZOOM TIME FRAME 0
1	Sets time frame number 0.5.	ZOOM TIME FRAME 1
2	Sets time frame number 1.	ZOOM TIME FRAME 2
3	Sets time frame number 1.5.	ZOOM TIME FRAME 3
4	Sets time frame number 2.	ZOOM TIME FRAME 4
↓	↓	↓
63	Sets time frame number 31.5	ZOOM TIME FRAME 63
?	Reads the ZTM setting.	0 - 63

10.8.6 Commands for 1/3-octave Band Analysis

These commands are valid when an optional expansion memory is mounted.

Start Analysis command

OST	Starts or stops the 1/3-octave BAND analysis.	o
0	Stops the 1/3-octave BAND analysis.	OCTAVE STOP
1	Starts the 1/3-octave BAND analysis.	OCTAVE START
?	Reads the OST setting.	0,1

Octave Range command

ORG	Sets the 1/3-octave BAND analysis range.	o
0	Sets the low analysis range.	LOW RANGE
1	Sets the high analysis range.	HIGH RANGE
?	Reads the ORG setting.	0,1

A Weight On/Off command

OAW	Sets the frequency compensating characteristic A (A weight)	o
0	Turns off A weight.	A-WEIGHT OFF
1	Turns on A weight.	A-WEIGHT ON
?	Reads the OAW setting.	0,1

10.9 Sample Programs

10.9.1 Connecting the PC9801-19 with the GP-IB Interface

(1) Initialization

Specify the address and delimiter for the PC9801-19 and for the FFT analyzer's GP-IB. The sample programs below run under the following settings:

	Address	Delimiter
PC-9801-19	8	EOI
FFT analyzer	0	EOI

Execute the following instructions at the beginning of each program:

```
10   ISET IFC
20   ISET REN
30   CMD DELIM=3
```

(2) Interactive program

When a computer specifies panel settings for the FFT analyzer or reads parameters from there, there are two ways to transmit necessary commands: either the program outputs commands, or an operator types commands for transmission. The later case applies where a GP-IB program is being developed, or where each command needs to be individually executed for verification of its performance. At this time, the program below is very convenient to run. (This program will also be used in (3) through (5) below.)

```
10  INPUT "COMMAND ";COMMAND$
20  PRINT @0 ; COMMAND$ @
30  LINE INPUT @0 ; TALK$
40  PRINT "                        "+TALK$
50  GOTO 10
```


(3) Transmitting panel control commands

Below are examples of transmitting commands that control the panel by utilizing the program described in (2) above.

i) "VIW" command
COMMAND? VIW1

TIME

ii) "CSR" command
COMMAND? CSR123

CURSOR 123

iii) "MID" command
COMMAND? MID1234 5

MEMORY ID 1234

iv) "ARA" command
COMMAND? ARA010 80 90 70 75

AREA 0 ON PEAK 80 90 70 75

Likewise, other commands may control the analyzer panel according to their functions when input through the keyboard. In the examples above, the underlines indicate the portions to be input manually through the keyboard. After typing a command, press the CR key. All commands except for those handling binary parameters can be sent in this manner. If it is desired to have a command transmitted halfway through program run without manual keystrokes, the program below is required.

```
10  PRINT @0 ; COMMAND$ @
20  LINE INPUT @0 ; TALK$
30  PRINT "                      "+TALK$
```

* If data need not be read, line 30 is not necessary.

(4) Transmitting commands for reading parameters.
Below are examples of transmitting commands that read parameters by utilizing the program described in (2) above.

i) "VIW" command
COMMAND? VIW?

1

ii) "AVG" command
COMMAND? AVG?

2

iii) "MPT" command

COMMAND? MPT?5

1

iv) "ARO" command

COMMAND? ARO?

0 1 0 80 90 70 75

Likewise, other commands cause parameters to be read according to their functions when input through the keyboard. In the examples above, the underlines indicate the portions to be input manually through the keyboard. After typing a command, press the CR key. All commands except for those receiving binary parameters can be sent in this manner. If it is desired to have a command transmitted halfway through program run to place a parameter in a variable without manual keystrokes, the program below is required.

```
10  PRINT @0 ; COMMAND$ @
20  LINE INPUT @0 ; TALK$
```

(5) Reading cursor values

Below are examples of transmitting commands for reading cursor values by utilizing the program described in (2) above.

COMMAND? RCS 0

CSR "+PK:", XVL2. 715mSEC, YVL 0.001 V

With the "CDP 1" command transmitted, the command format is as follows.

COMMAND? CDP 1

CURSOR DISPLAY 1

COMMAND? RCS 0

CSR 0, 2 2. 714E - 03, 1 3. 905E - 4

The underlines indicate the portions to be input manually through the keyboard. After typing a command, press the

CR key. If it is desired to have a command transmitted halfway through program run to place a parameter in a variable without manual keystrokes, the program below is required.

```
10  PRINT @0 ; COMMAND$ @
20  LINE INPUT @0 ; TALK$
```

(6) Transmit measured data, display and panel memory data. Below are examples of commands for getting the FFT analyzer to transmit binary data. There are three such commands: MDD, PLD, and WDD. The program used in (2) above does not apply here. Instead, the description of each command is accompanied by a sample program.

i) MDD command

In this example, the MDD command is used to transfer the contents of screen memory No. 1 to the computer for storage in a variable.

```
10          DIM INBUFFER%(1500)
20          PRINT @0 ; "MDD 1" @
30          WBYTE &H28,&H40;
40          FOR LOOP = 0 TO 1445 : RBYTE ; INBUFFER%(LOOP)  : NEXT LOOP
```

<u>Explanation</u>

10: A large enough array is declared for allocation of the data area.

20: The "MDD 1" command is transmitted.

30: The FFT analyzer is designated as talker, and the computer as listener.

40: A total of 1446 data items are placed in the array.

ii) PLD command

In this example, the PLD command is used to transfer the contents of panel memory No. 2 to the computer for storage in a variable.

```
10          DIM INBUFFER%(1500)
20          PRINT @0 ; "PLD 2" @
30          WBYTE &H28,&H40;
40          FOR LOOP = 0 TO 421  : RBYTE ; INBUFFER%(LOOP)  : NEXT LOOP
```

Explanation

10: A large enough array is declared for allocation of the data area.

20: The "PLD 2" command is transmitted.

30: The FFT analyzer is designated as talker, and the computer as listener.

40: A total of 422 data items are placed in the array.

iii) WDD command

The data sent back by the WDD command varies in length and type depending on the waveform displayed on the FFT analyzer. The sample programs below are keyed to the different waveform types displayed.

a. Time display on FFT analyzer

```
10    DIM INBUFFER%(1500)
20    PRINT @0 ; "WDD ?" @
30    WBYTE &H28,&H40;
40    FOR LOOP = 0 TO 1025 : RBYTE ; INBUFFER%(LOOP)  : NEXT LOOP
```

Explanation

10: A large enough array is declared for allocation of the data area.

20: The "WDD?" command is transmitted.

30: The FFT analyzer is designated as talker, and the computer as listener.

40: A total of 1026 data items are placed in the array.

b. Histogram display on FFT analyzer

```
10    DIM INBUFFER%(1500)
20    PRINT @0 ; "WDD ?" @
30    WBYTE &H28,&H40;
40    FOR LOOP = 0 TO 257  : RBYTE ; INBUFFER%(LOOP)  : NEXT LOOP
```

Explanation

10: A large enough array is declared for allocation of the data area.

20: The "WDD?" command is transmitted.

30: The FFT analyzer is designated as talker, and the computer as listener.

40: A total of 258 data items are placed in the array.

c. Spectrum display on FFT analyzer.

c-1. For magnitude display

```
10    DIM INBUFFER%(1500)
20    PRINT @0;"WDD ?" @
30    WBYTE &H28,&H40;
40    FOR LOOP = 0 TO 805 : RBYTE ; INBUFFER%(LOOP) : NEXT LOOP
```

Explanation

10: A large enough array is declared for allocation of the data area.

20: The "WDD?" command is transmitted.

30: The FFT analyzer is designated as talker, and the computer as listener.

40: A total of 806 data items are placed in the array.

c-2. For phase display

```
10          DIM INBUFFER%(1500)
20          PRINT @0 ; "WDD ?" @
30          WBYTE &H28,&H40;
40          FOR LOOP = 0 TO 403  : RBYTE ; INBUFFER%(LOOP)  : NEXT LOOP
```

Explanation

10: A large enough array is declared for allocation of the data area.

20: The "WDD?" command is transmitted.

30: The FFT analyzer is designated as talker, and the computer as listener.

40: A total of 404 data items are placed in the array.

(7) Returning data to FFT analyzer

Below are examples of commands for returning binary data to the FFT analyzer. There are three such commands: BTM, BMD, and BPL. The "BMD" and "BPL" commands are used to return to the analyzer the data that was sent in by the "MDD" or "PLD" command in (6) above. This means that the data received by the use of the "MDD" or "PLD" command can be used unchanged as parameters for the "BMD" or "BPL" command. The "BTM" command may employ either the time data received by the use of the "WDD" command, or new data obtained through calculations.

i) BTM command

The BTM command is used to have the computer transmit time data. At this time, the FFT analyzer must be in a hold state. In the sample program below, it is assumed that the data to be transmitted is already in DATUM%(n).

```
10      FOR LOOP = 6 TO 1029
20             INBUFFER%(LOOP) = DATUM%(LOOP-6)
30      NEXT LOOP
40      INBUFFER%(0) = ASC("B") : INBUFFER%(1) = ASC("T")
50      INBUFFER%(2) = ASC("M") : INBUFFER%(3) = ASC(" ")
60      INBUFFER%(4) = ASC("#") : INBUFFER%(5) = ASC("I")
70      WBYTE &H48,&H20;
80      FOR LOOP=0 TO 1028 : WBYTE ; INBUFFER%(LOOP) : NEXT LOOP
90      WBYTE ; INBUFFER%(1029) @
```

Explanation

10-30: The contents of DATUM%(n-6) are transferred to INBUFFER%(n).

40-60: "BTM#I" is placed in INBUFFER%(0) through INBUFFER%(5).

70: The FFT analyzer is designated as listener, and the computer as talker.

80: The contents of INBUFFER%(n) are transmitted by 1029 bytes to the analyzer.

90: The last one byte is transmitted together with EOI.

ii) BMD command

The BMD command is used to transmit data to screen memory No. 4. In the sample program below, it is assumed that the data to be transmitted is already in DATUM%(n).

```
10      FOR LOOP = 8 TO 1451
20             INBUFFER%(LOOP) = DATUM%(LOOP-8)
30      NEXT LOOP
40      INBUFFER%(0) = ASC("B") : INBUFFER%(1) = ASC("M")
50      INBUFFER%(2) = ASC("D") : INBUFFER%(3) = ASC(" ")
60      INBUFFER%(4) = ASC("#") : INBUFFER%(5) = ASC("I")
70      INBUFFER%(6) = 0        : INBUFFER%(7) = 4
80      WBYTE &H48,&H20;
90      FOR LOOP=0 TO 1450 : WBYTE ; INBUFFER%(LOOP) : NEXT LOOP
100     WBYTE ; INBUFFER%(1451) @
```

Explanation

10-30: The contents of DATUM%(n-8) are transferred to INBUFFER%(n).

40-70: "BMD#I" 04 is placed in INBUFFER%(0) through INBUFFER%(7).

80: The FFT analyzer is designated as listener, and the computer as talker.

90: The contents of INBUFFER%(n) are transmitted by 1451 bytes to the analyzer.

100: The last one byte is transmitted together with EOI.

iii) The BPL command is used to transmit data to panel memory No. 3. In the sample program below, it is assumed that the data to be transmitted is already in DATUM%(n).

```
10        FOR LOOP = 8 TO 427
20             INBUFFER%(LOOP) = DATUM%(LOOP-8)
30        NEXT LOOP
40        INBUFFER%(0) = ASC("B") : INBUFFER%(1) = ASC("P")
50        INBUFFER%(2) = ASC("L") : INBUFFER%(3) = ASC(" ")
60        INBUFFER%(4) = ASC("#") : INBUFFER%(5) = ASC("I")
70        INBUFFER%(6) = 0        : INBUFFER%(7) = 3
80        WBYTE &H48,&H20;
90        FOR LOOP=0 TO 426  : WBYTE ; INBUFFER%(LOOP) : NEXT LOOP
100        WBYTE ; INBUFFER%(427) @
```

Explanation

10-30: The contents of DATUM%(n-8) are transferred to INBUFFER%(n).

40-70: "BPL#I" 03 is placed in INBUFFER%(0) through INBUFFER%(7).

80: The FFT analyzer is designated as listener, and the computer as talker.

90: The contents of INBUFFER%(n) are transmitted by 427 bytes to the analyzer.

100: The last one byte is transmitted together with EOI.

(8) Example of SRQ transmission

Below is an example of having the FFT analyzer terminate averaging and transmit SRQ at the same time.

```
10      ON SRQ GOSUB 1000
20      SRQ ON
30      PRINT @0;"VIW 0 SQM 8 AVN 5 AVM 0 AVD 0 AVG 0 AVI 1" @
40    '
50      GOTO 40
1000    POLL 0,DATUM
1010    PRINT "AVERAGE END ! "
1020    SRQ ON
1030    RETURN
```

This program executes averaging 64 times in the spectrum "SUMN" mode and, at the end of the averaging, causes message "AVERAGE END!" to be displayed.

Explanation

10: A routine is set to handle SRQ when it occurs.

20: SRQ transmission is enabled.

30: The FFT analyzer is instructed to provide a spectrum display, enable SRQ transmission, perform averaging 64 times, perform SUMN mode averaging, start averaging, and display average waveforms.

40: Nothing is carried out.

50: A jump is made to line 40.

1000: The status byte is read from the analyzer.

1010: A message is displayed.

1020: The next SRQ transmission is enabled.

(9) Sample program of file processing

The data sent in from the FFT analyzer is stored in files. Or, the contents of the files are transmitted to the analyzer.

```
10  ' ~~~~~~~~~~~~~~~~ INITIALIZATION PART ~~~~~~~~~~~~~~~~~~
20  '
30            CLS 3
40            ISET IFC
50            ISET REN
60            SRQ OFF
70            ON SRQ GOSUB *SRQSV
80            SRQ ON
90            DIM INBUFFER%(1500)
100           INPUT "ADDRESS ";FFT
110           INPUT "DELIMITER (0:CR+LF+EOI 2:LF+EOI 3:EOI) ";DLMT
120           CMD DELIM=DLMT
130 '
140 ' ~~~~~~~~~~~~~~~ MAIN ROUTINE ~~~~~~~~~~~~~~~~~~~~~~~~~
150 '
160           CLS 3
170 *MLOOP    INPUT "COMMAND ";COMMAND$
180           IF COMMAND$="BTM"  THEN GOSUB *BTMPRC
190           IF COMMAND$="WDD"  THEN GOSUB *WDDPRC
200           IF COMMAND$="MDD"  THEN GOSUB *MDDPRC
210           IF COMMAND$="BMD"  THEN GOSUB *BMDPRC
220           IF COMMAND$="BPL"  THEN GOSUB *BPLPRC
230           IF COMMAND$="PLD"  THEN GOSUB *PLDPRC
240           PRINT @FFT;COMMAND$ @
250           LINE INPUT @FFT;TALK$
260           PRINT "                    "+TALK$
270 *MAIN     GOTO *MLOOP
280 '
290 ' ~~~~~~~~~~~~~~~ BINARY TIME DATA SEND ~~~~~~~~~~~~~~~~
300 '
310 *BTMPRC:  INPUT "FILE ";FILE$
320           OPEN FILE$ FOR INPUT AS #1
330           FOR LOOP = 6 TO 1029 : INPUT #1,INBUFFER%(LOOP) : NEXT LOOP
340           INBUFFER%(0) = ASC("B") : INBUFFER%(1) = ASC("T")
350           INBUFFER%(2) = ASC("M") : INBUFFER%(3) = ASC(" ")
360           INBUFFER%(4) = ASC("#") : INBUFFER%(5) = ASC("I")
370           WBYTE &H48,&H20+FFT;
380           FOR LOOP=0 TO 1028 : WBYTE ; INBUFFER%(LOOP) : NEXT LOOP
390           WBYTE ; INBUFFER%(1029) @
400           CLOSE #1
410           RETURN *MAIN
420 '
430 ' ~~~~~~~~~~~~~~~ WAVE DATA RECEIVE ROUTINE ~~~~~~~~~~~~~
440 '
450 *WDDPRC:  PRINT @FFT ; "VIW ?" @
460           INPUT @FFT;DOMAIN
470           ON DOMAIN+1 GOSUB *SPDPRC,*TMDPRC,*HSDPRC
480 '
490 *TMDPRC:      INPUT "FILE ";FILE$
500               OPEN FILE$ FOR OUTPUT AS #1
510               PRINT @FFT;"WDD ?" @
520               WBYTE &H28,&H40+FFT;
530               FOR LOOP = 0 TO 1025 : RBYTE ; INBUFFER%(LOOP)  : NEXT LOOP
540               FOR LOOP = 2 TO 1025 : PRINT #1,INBUFFER%(LOOP) : NEXT LOOP
550               CLOSE #1
560               RETURN *MAIN
570 '
580 *HSDPRC:      INPUT "FILE ";FILE$
590               OPEN FILE$ FOR OUTPUT AS #1
600               PRINT @FFT;"WDD ?" @
610               WBYTE &H28,&H40+FFT;
620               FOR LOOP = 0 TO 257  : RBYTE ; INBUFFER%(LOOP)  : NEXT LOOP
630               FOR LOOP = 2 TO 257  : PRINT #1,INBUFFER%(LOOP) : NEXT LOOP
640               CLOSE #1
```

```
650                 RETURN *MAIN
660 '
670 *SPDPRC:        PRINT @FFT;"MGP ?" @
680                 INPUT @FFT;PHASE
690                 ON PHASE+1 GOSUB *PWDPRC,*PHDPRC
700 *PHDPRC:        INPUT "FILE ";FILE$
710                 OPEN FILE$ FOR OUTPUT AS #1
720                 PRINT @FFT; "WDD ?" @
730                 WBYTE &H28,&H40+FFT;
740                 FOR LOOP = 0 TO 403   : RBYTE ; INBUFFER%(LOOP)   : NEXT LOOP
750                 FOR LOOP = 2 TO 403   : PRINT #1,INBUFFER%(LOOP) : NEXT LOOP
760                 CLOSE #1
770                 RETURN *MAIN
780 *PWDPRC:        INPUT "FILE ";FILE$
790                 OPEN FILE$ FOR OUTPUT AS #1
800                 PRINT @FFT; "WDD ?" @
810                 WBYTE &H28,&H40+FFT;
820                 FOR LOOP = 0 TO 805   : RBYTE ; INBUFFER%(LOOP)   : NEXT LOOP
830                 FOR LOOP = 2 TO 805   : PRINT #1,INBUFFER%(LOOP) : NEXT LOOP
840                 CLOSE #1
850                 RETURN *MAIN
860 '
870 '~~~~~~~~~~~~~~~~~ MEMORY DATA RECEIVE RUTINE ~~~~~~~~~~~~~~~
880 '
890 *MDDPRC:   INPUT "FILE ";FILE$
900            OPEN FILE$ FOR OUTPUT AS #1
910            INPUT "MEMORY NO. "; MEM
920            PRINT @FFT; "MDD "+STR$(MEM) @
930            WBYTE &H28,&H40+FFT;
940            FOR LOOP = 0 TO 1445 : RBYTE ; INBUFFER%(LOOP)   : NEXT LOOP
950            FOR LOOP = 2 TO 1445 : PRINT #1,INBUFFER%(LOOP) : NEXT LOOP
960            CLOSE #1
970            RETURN *MAIN
980 '
990 '~~~~~~~~~~~~~~~~~~ MEMORY DATA SEND ROUTINE ~~~~~~~~~~~~~~~~~
1000 '
1010 *BMDPRC:   INPUT "FILE ";FILE$
1020            INPUT "MEMORY NO.";MEM
1030            OPEN FILE$ FOR INPUT AS #1
1040            FOR LOOP = 8 TO 1451 : INPUT #1,INBUFFER%(LOOP) : NEXT LOOP
1050            INBUFFER%(0) = ASC("B") : INBUFFER%(1) = ASC("M")
1060            INBUFFER%(2) = ASC("D") : INBUFFER%(3) = ASC(" ")
1070            INBUFFER%(4) = ASC("#") : INBUFFER%(5) = ASC("I")
1080            INBUFFER%(6) = 0        : INBUFFER%(7) = MEM
1090            WBYTE &H48,&H20+FFT;
1100            FOR LOOP=0 TO 1450 : WBYTE ; INBUFFER%(LOOP) : NEXT LOOP
1110            WBYTE ; INBUFFER%(1451) @
1120            CLOSE #1
1130            RETURN *MAIN
1140 '
1150 '~~~~~~~~~~~~~~~~~~ PANEL DATA SEND ROUTINE ~~~~~~~~~~~~~
1160 '
1170 *BPLPRC:   INPUT "FILE ";FILE$
1180            INPUT "PANEL  NO.";PANEL
1190            OPEN FILE$ FOR INPUT  AS #1
1200            FOR LOOP = 8 TO 427  : INPUT #1,INBUFFER%(LOOP) : NEXT LOOP
1210            INBUFFER%(0) = ASC("B") : INBUFFER%(1) = ASC("P")
1220            INBUFFER%(2) = ASC("L") : INBUFFER%(3) = ASC(" ")
1230            INBUFFER%(4) = ASC("#") : INBUFFER%(5) = ASC("I")
1240            INBUFFER%(6) = 0        : INBUFFER%(7) = PANEL
1250            WBYTE &H48,&H20+FFT;
1260            FOR LOOP=0 TO 426  : WBYTE ; INBUFFER%(LOOP) : NEXT LOOP
1270            WBYTE ; INBUFFER%(427) @
1280            CLOSE #1
1290            RETURN *MAIN
1300 '
```

```
1310 '~~~~~~~~~~~~~~~~~~ PANEL DATA RECEIVE ROUTINE ~~~~~~~~~~~~
1320 '
1330 *PLDPRC:  INPUT "FILE ";FILE$
1340           OPEN FILE$ FOR OUTPUT AS #1
1350           INPUT "PANEL  NO. "; PANEL
1360           PRINT @FFT; "PLD "+STR$(PANEL) @
1370           WBYTE &H28,&H40+FFT;
1380           FOR LOOP = 0 TO 421 : RBYTE ; INBUFFER%(LOOP)  : NEXT LOOP
1390           FOR LOOP = 2 TO 421 : PRINT #1,INBUFFER%(LOOP) : NEXT LOOP
1400           CLOSE #1
1410           RETURN *MAIN
1420           RETURN
1430 '
1440 ' ~~~~~~~~~~~~~~~~~~ SRQ SERVICE ROUTINE ~~~~~~~~~~~~~~~~~
1450 '
1460  *SRQSV: POLL FFT,STB
1470          PRINT "SRQ RECEIVED FROM ";FFT;" MESSAGE = ";HEX$(STB)
1480          SRQ ON
1490          RETURN
```

10.9.2 Connecting the HP9000 Series Model 216 with the GP-IB Interface

(1) Initialization

Specify the address for the HP9000 model 216, and the address and delimiter for the FFT analyzer's GP-IB. The sample programs below run under the following settings:

	Address	Delimiter
HP9000 model 216	21	As programmed
FFT analyzer	0	EOI

*Connect the GP-IB to select cord 8 from the model 216's interface.

Execute the following instructions at the beginning of each program.

```
10   ABORT 8
20   ASSIGN @Fft TO 800
30   REMOTE @Fft
```

(2) Interactive program

When a computer specifies panel settings for the FFT analyzer or reads parameters from there, there are two ways to transmit necessary commands: either the program outputs commands, or an operator types commands for transmission. The latter case applies where a GP-IB program is being developed, or where each command needs to be individually executed for verification of its performance. At this time, the program below is very convenient to run. (This program will also be used in (3) through (5) below.)

```
10    DIM Talk$[60],Command$[60]
20    INPUT "COMMAND = ?",Command$
30    OUTPUT @Fft;Command$ END
40    ENTER @Fft;Talk$
50    PRINT Talk$
60    GOTO 20
70    END
```

(3) Transmitting panel control commands

Below are examples of transmitting commands that control the panel by utilizing the program described in (2) above.

i) "VIW" command

COMMAND=? VIW 1

TIME

ii) "CSR" command

COMMAND=? CSR 123

CURSOR 123

iii) "MID" command

COMMAND=? MID 1234 5

MEMORY ID 1234

iv) "ARA" command

COMMAND=? ARA 0 1 0 80 90 70 75

AREA 0 ON PEAK 80 90 70 75

Likewise, other commands may control the analyzer panel according to their functions when input through the keyboard. In the examples above, the underlines indicate the portions to be input manually through the keyboard. After typing each underlined portion, press the ENTER key. All commands except for those handling binary parameters can be sent in this manner. If it is desired to have a command transmitted halfway through program run without manual keystrokes, the program below is required.

```
10      DIM Talk$[60]
20      OUTPUT @Fft;Command$ END
30      ENTER @Fft;Talk$
40      PRINT Talk$
```

* If data need not be read, lines 30 and 40 are not necessary.

(4) Transmittitng commands for reading parameters
Below are examples of transmitting commands that read parameters by utilizing the program described in (2) above.

i) "VIW" command

COMMAND=? VIW?

1

ii) "AVG" command

COMMAND=? AVG?

2

iii) "MPT" command

COMMAND=? MPT?5

1

iv) "ARO" command

COMMAND=? ARO?

0 1 0 80 90 70 75

Likewise, other commands cause parameters to be read according to their functions when input through the keyboard. In the examples above, the underlines indicate the portions to be input manually through the keyboard.
After typing each underlined portion, press the ENTER key. All commands except for those receiving binary parameters can be sent in this manner. If it is desired to have a command transmitted halfway through program run to place a parameter in a variable without manual keystrokes, the program below is required.

```
10      DIM Talk$[60]
20      OUTPUT @Fft;Command$ END
30      ENTER @Fft;Talk$
```

(5) Reading cursor values

Below are examples of transmitting commands for reading cursor values by utilizing the program described in (2) above.

```
COMMAND=?
RCSO          CSR "+PK:", XVL 2. 715mSEC, YVL, 0. 001V
```

With the "CDP1" command transmitted, the command format is as follows.

```
COMMAND?
CDP 1         CURSOR DISPLAY 1
COMMAND?
RCS 0         CSR 0, 2 2. 714E - 3, 1 6. 905 E - 4
```

The underlines indicate the portions to be input manually through the keyboard. After typing each underlined portion, press the ENTER key. If it is desired to have a command transmitted halfway through program run to place a parameter in a veriable without manual keystrokes, the program below is required.

```
10    DIM Talk$[60]
20    OUTPUT @Fft;Command$ END
30    ENTER @Fft;Talk$
```

(6) Transmitting measured data, memory and panel memory data.

Below are examples of commands for getting the FFT analyzer to transmit binary data. There are three such commands: MDD, PLD, and WDD. The program used in (2) above does not apply here. Instead, the description of each command is accompanied by a sample program.

i) MDD command

In this example, the MDD command is used to transfer the contents of screen memory No. 1 to the computer for storage in a variable.

```
10    INTEGER Datum(722)
20    OUTPUT @Fft;"MDD 1" END
30    ENTER @Fft USING "#,W";Datum(*)
```

Explanation

10: An array is declared for allocation of the data area.

20: The "MDD1" command is transmitted to the FFT analyzer.

30: Data of 1466 bytes is received from the analyzer.

ii) PLD command

In this example, the PLD command is used to transfer the contents of panel memory No. 2 to the computer for storage in a variable.

```
10    INTEGER Datum(210)
20    OUTPUT @Fft;"PLD 2" END
30    ENTER @Fft USING "#,W";Datum(*)
```

Explanation

10: An array is declared for allocation of the data area.

20: The "PLD 2" command is transmitted to the FFT analyzer.

30: Data of 422 bytes is received from the analyzer.

iii) WDD command

The data sent back by the WDD command varies in length and type depending on the waveform displayed on the FFT analyzer. The sample programs below are keyed to the different waveform types displayed.

a. Time display on FFT analyzer

```
10    INTEGER Datum(512)
20    OUTPUT @Fft;"WDD ?" END
30    ENTER @Fft USING "#,W";Datum(*)
```

Explanation

10: An array is declared for allocation of the data area.

20: The "WDD?" command is transmitted to the FFT analyzer.

30: Data of 1026 bytes is received from the analyzer.

b. Histogram display on FFT analyzer

```
10      INTEGER Datum(128)
20      OUTPUT @Fft;"WDD ?" END
30      ENTER @Fft USING "#,W";Datum(*)
```

Explanation

10: An array is declared for allocation of the data area.

20: The "WDD?" command is transmitted to the FFT analyzer.

30: Data of 258 bytes is received from the analyzer.

c. Spectrum display on FFT analyzer

c-1. For magnitude display

```
10      INTEGER Datum(402)
20      OUTPUT @Fft;"WDD ?" END
30      ENTER @Fft USING "#,W";Datum(*)
```

Explanation

10: An array is declared for allocation of the data area.

20: The "WDD?" command is transmitted to the FFT analyzer.

30: Data of 806 bytes is received from the analyzer.

c-2. For phase display

```
10      INTEGER Datum(201)
20      OUTPUT @Fft;"WDD ?" END
30      ENTER @Fft USING "#,W";Datum(*)
```

Explanation

10: An array is declared for allocation of the data area.

20: The "WDD?" command is transmitted to the FFT analyzer.

30: Data of 404 bytes is received from the analyzer.

(7) Returning data to FFT analyzer

Below are examples of commands for returning binary data to the FFT analyzer. There are three such commands: BTM, BMD, and BPL. The "BMD" and "BPL" commands are used to return to the analyzer the data that was sent in by the "MDD" or"PLD" command in (6) above. This means that the data received by the use of the "MDD" or "PLD" command can be used unchanged as parameters for the "BMD" or "BPL" command. The "BTM" command may employ either the time data received by the use of the "WDD" command, or new data obtained through calculations.

i) BTM command

The BTM command is used to have the computer transmit time data. At this time, the FFT analyzer must be in a hold state. In the sample program below, it is assumed that the data to be transmitted is already in DATUM(*).

```
10    OUTPUT @Fft;"BTM #I";
20    OUTPUT @Fft USING "W";Datum(*) END
```

Explanation

10: "BTM#I" is transmitted to the FFT analyzer.

20: Time data of 1024 bytes is then transmitted to the analyzer.

* It is assumed that DATUM(*) is declared to be INTEGER(511).

ii) BMD command

The BMD command is used to transmit data to scren memory No. 4. In the sample program below, it is assumed that the data to be transmitted is already in DATUM(*).

```
10    OUTPUT @Fft;"BMD #I";
20    OUTPUT @Fft USING "W,W";4,Datum(*) END'
```

Explanation

10: "BMD#I" is transmitted to the FFT analyzer.

20: The memory number and memory data, 1446 bytes in total, are transmitted.

* It is assumed that DATUM(*) is declared to be INTEGER DATUM(721).

iii) BPL command

The BPL command is used to transmit data to panel memory No. 3. In the sample program below, it is assumed that the data to be transmitted is already in DATUM(*).

```
10    OUTPUT @Fft;"BPL #I";
20    OUTPUT @Fft USING "W,W";3,Datum(*) END
```

Explanation

10: "BPL#I" is transmitted to the FFT analyzer.

20: The panel number and panel data, 422 bytes in total, are transmitted .

* It is assumed that DATUM(*) is declared to be INTEGER DATUM(209).

(8) Example of SRQ transmission

Below is an example of having the FFT analyzer terminate averaging and transmit SRQ at the same time.

```
10    ON INTR 8 GOSUB Srqserv
20    ENABLE INTR 8;2
30    ASSIGN @Fft TO 800
40    ABORT 8
50    REMOTE @Fft
60    OUTPUT @Fft;"VIW 0 SQM 8 AVN 5 AVM 0 AVD 0 AVG 0 AVI 1" END
70    !
80    GOTO 70
90 Srqserv:     Stb=SPOLL(@Fft)
100             PRINT "AVERAGE END ! "
110             ENABLE INTR 8
120             RETURN
130   END
```

This program executes averaging 64 times in the spectrum "SUMN" mode and, at the end of the averaging, causes message "AVERAGE END 1" to be displayed.

Explanation

10: A routine is set to handle SRQ when it occurs.

20: An interruption is generated when SRQ is received from the interface via select code 8.

30: An I/O path attribute "@Fft" is attached to device No. 800.

40: An interface clear signal is placed on interface select code 8.

50: The FFT analyzer is placed in the remote mode.

60: The FFT analyzer is instructed to provide a spectrum display, enable SRQ transmission, perform averaging 64 times, perform SUMN mode averaging, start averaging, and display average waveforms.

70: Nothing is carried out.
80: A jump is made to line 70.
90: The status byte is read from the analyzer.
100: A message is displayed.
110: The next interruption is enabled.

(9) Sample program of file processing
The data sent in from the FFT analyzer is stored in files. Or, the contents of the files are transmitted to the analyzer.

```
10      DIM Talk$[60],Command$[60]
20      INTEGER Datum(740),Buf(740)
30      ON INTR 8 GOSUB Srqserv
40      ENABLE INTR 8;2
50      ASSIGN @Fft TO 800
60      INPUT "ADDRESS  ?",Address
70      Address=Address+800
80      ASSIGN @Fft TO Address
90      ABORT 8
100     REMOTE @Fft
110 Main_loop:  INPUT "COMMAND =  ?",Command$
120             SELECT Command$
130                CASE "BTM"
140                   GOSUB Btmprc
150                CASE "BMD"
160                   GOSUB Bmdprc
170                CASE "BPL"
180                   GOSUB Bplprc
190                CASE "WDD"
200                   GOSUB Wddprc
210                CASE "MDD"
220                   GOSUB Mddprc
230                CASE "PLD"
240                   GOSUB Pldprc
250                CASE ELSE
260                   OUTPUT @Fft;Command$ END
270                   ENTER @Fft;Talk$
280                   PRINT Talk$
290             END SELECT
300             GOTO Main_loop
310     ! ________________ BTM PROCEDURE ________________
320     !
340 Btmprc:    REDIM Datum(511)
350            INPUT "FILE NAME. ?",File$
360            ASSIGN @File TO File$
370            ENTER @File;Datum(*)
380            OUTPUT @Fft;"BTM #I";
390            OUTPUT @Fft USING "W";Datum(*) END
400            ASSIGN @File TO *
410            RETURN
411     ! ________________ BMD PROCEDURE ________________
412     !
430 Bmdprc:    REDIM Datum(721)
440            INPUT "MEMORY NO. ?",Mem
450            INPUT "FILE NAME ? ",File$
460            ASSIGN @File TO File$
470            ENTER @File;Datum(*)
480            OUTPUT @Fft;"BMD #I";
490            OUTPUT @Fft USING "W,W";Mem,Datum(*) END
500            ASSIGN @File TO *
510            RETURN
511     ! ________________ BPL PROCEDURE ________________
512     !
530 Bplprc:    REDIM Datum(209)
540            INPUT "PANEL NO. ?",Pnl
550            INPUT "FILE NAME ?",File$
560            ASSIGN @File TO File$
570            ENTER @File;Datum(*)
```

```
580              OUTPUT @Fft;"BPL #I";
590              OUTPUT @Fft USING "W,W";Pnl,Datum(*) END
600              ASSIGN @File TO *
610              RETURN
611    ! ____________________ MDD PROCEDURE ____________________
612    !
630 Mddprc:      REDIM Datum(722),Buf(721)
640              INPUT "MEM NO ?",Mem
650              OUTPUT @Fft;"MDD";Mem END
660              ENTER @Fft USING "#,W";Datum(*)
670              FOR I=0 TO 721
680                 Buf(I)=Datum(I+1)
690              NEXT I
700              GOSUB Filestr
710              RETURN
711    ! ____________________ PLD PROCEDURE ____________________
712    !
730 Pldprc:      REDIM Datum(210),Buf(209)
740              INPUT "PANEL NO ?",Pnl
750              OUTPUT @Fft;"PLD";Pnl END
760              ENTER @Fft USING "#,W";Datum(*)
770              FOR I=0 TO 209
780                 Buf(I)=Datum(I+1)
790              NEXT I
800              GOSUB Filestr
810              RETURN
811    ! ____________________ WDD PROCEDURE ____________________
812    !
820 Wddprc:      OUTPUT @Fft;"VIW ?" END
830              ENTER @Fft;Domain
840              SELECT Domain
850                 CASE 0
860                    GOSUB Specprc
870                 CASE 1
880                    GOSUB Timeprc
890                 CASE 2
900                    GOSUB Histprc
910              END SELECT
920              RETURN
930 Timeprc:     REDIM Datum(512),Buf(511)
940              OUTPUT @Fft;"WDD ?" END
950              ENTER @Fft USING "#,W";Datum(*)
960              FOR I=0 TO 511
970                 Buf(I)=Datum(I+1)
980              NEXT I
990              GOSUB Filestr
1000             RETURN
1010 Histprc:    REDIM Datum(128),Buf(127)
1020             OUTPUT @Fft;"WDD ?" END
1030             ENTER @Fft USING "#,W";Datum(*)
1040             FOR I=0 TO 127
1050                Buf(I)=Datum(I+1)
1060             NEXT I
1070             GOSUB Filestr
1080             RETURN
1081 Specprc:    REDIM Datum(402),Buf(401)
1090             OUTPUT @Fft;"MGP ?" END
1100             ENTER @Fft;Phase
1110             IF Phase=1 THEN
1120                REDIM Datum(201),Buf(200)
1130                OUTPUT @Fft;"WDD ?" END
1140                ENTER @Fft USING "#,W";Datum(*)
1150                FOR I=0 TO 200
1160                   Buf(I)=Datum(I+1)
1170                NEXT I
1180                GOSUB Filestr
```

```
1190           ELSE
1200              REDIM Datum(402),Buf(401)
1210              OUTPUT @Fft;"WDD ?" END
1220              ENTER @Fft USING "#,W";Datum(*)
1230              FOR I=0 TO 401
1240                 Buf(I)=Datum(I+1)
1250              NEXT I
1260              GOSUB Filestr
1270           END IF
1280           RETURN
1281   ! __________________ FILE STORE PROCEDURE _____________
1282   !
1300 Filestr: INPUT "FILENAME ? ",File$
1310           CREATE BDAT File$,6,256
1320           ASSIGN @File TO File$
1330           OUTPUT @File USING "#,W";Buf(*)
1340           ASSIGN @File TO *
1350           RETURN
1351   ! __________________ SRQ SERVICE ROUTINE ______________
1352   !
1360 Srqserv: Stb=SPOLL(@Fft)
1370           PRINT "SRQ RECEIVED FROM FFT ,MESSAGE = ";Stb
1380           ENABLE INTR 8
1390           RETURN
1400 Finish:  END
```

CHAPTER 11. EXPANSION MEMORY (FUNCTION UNIT)

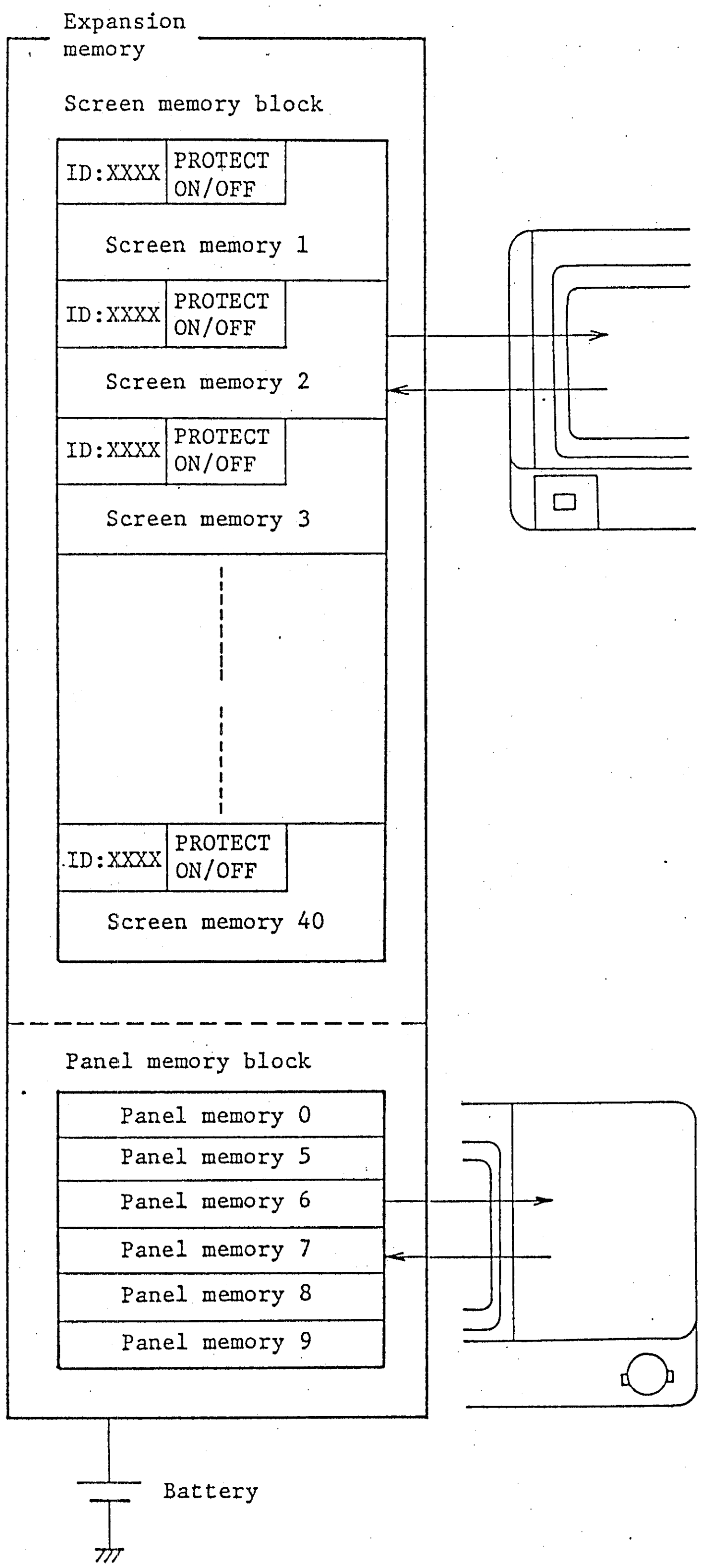
11.1 Outline

The FAE2000 ES01-FAE memory function unit is a battery-backed up expansion memory and function unit that may be incorporated in the FFT analyzer. When installed, this memory makes it possible to:

(1) Store up to 40 analyzer screens of waveforms and data,
(2) Store six more panel settings of the analyzer, in addition to the standard four,
(3) Display three-dimensional waveforms,
(4) Use zooming function (up to 32 times),
(5) Use 1/3-octave band analysis and "A" weighting functions,
(6) List the read-out of fundamental and harmonic frequency, and
(7) Use a cursor read-out for EU value.

Backed up by battery, the memory retains its contents after power is removed.
This option helps implement some new applications. For example, the data measured in the field can be brought back to the laboratory for detailed analysis at a later date.
Where the GP-IB is provided, the contents of the memory can be placed in files of an external controller or the like. The functions of 3-dimensional display and zooming use part of the picture memory as the work area. Therefore, the setup that permits the execution of 3-dimensional display or zooming decreases your usable picture memory area. See "11.4 Three-dimensional Display" and "11.5 Zoom" for details.
See "7.3.2.6 WIND Menu" for the list display described in item (6). See "8.4 Inputting the Engineering Unit (EU)" for setting up the EU value described in item (7).

11.2 Data Structure of Expansion Memory



The expansion memory consists of two parts: screen memory block and panel memory block.

Where the expansion memory is installed, the standard screen memory is regarded as screen memory No. 0.

The screen memory block is composed of 40 areas, numbered 1 through 40, each containing one piece of analyzer screen information.

Screen information refers to the waveform data being displayed and the parameters used for measurement.

Each screen memory area is assigned an ID number and a protect flag.

An ID number is an integer of up to 4 digits. It identifies each of the memory areas provided.

A protect flag is used to protect the data in a given memory area from destruction by updating. When the flag is turned on, it is impossible to write any data into the corresponding memory area.

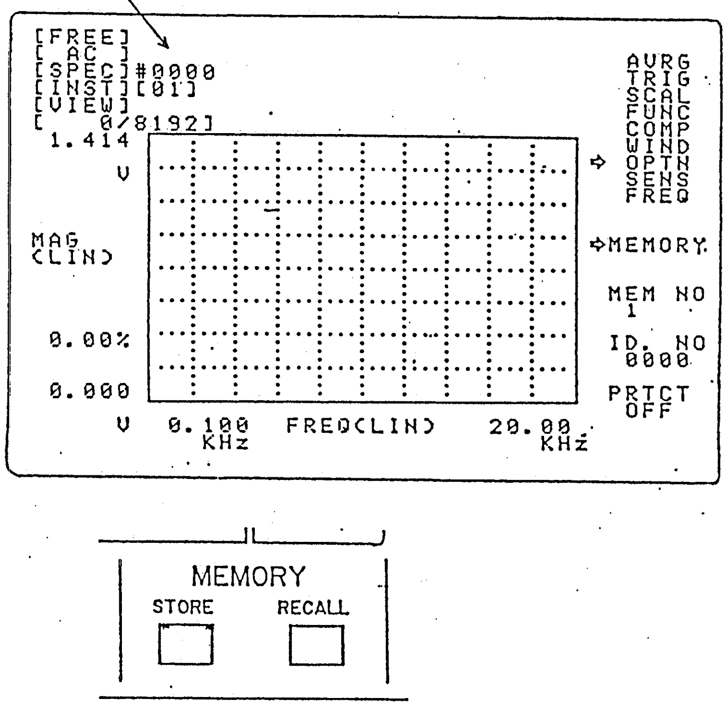
The panel memory block is made up of 6 areas, numbered 0 and 5 through 9, and forms an addition to the standard 4 areas provided.

Because the expansion memory is backed up by battery, it retains its contents for a month (Approximately) after power is removed.

11.3 Handling

[Memory indicator]

While a memory screen is being displayed, the ID number of the corresponding screen memory is indicated here. Pressing the STORE key displays the number of the screen memory to be stored next. Pressing the RECALL key displays the number of the preceding screen memory recalled.



[Memory number]

Data is stored and recalled to and from the memory whose number is set here.

[ID number]

A number set here is written in the screen memory as its ID number.

[Protect flag]

Turning this flag on inhibits writing data in the memory whose number is being displayed.

In the standard setup, one screen may be stored to and recalled from the screen memory. With the expansion memory optionally added, up to 40 screens may be stored and recalled.
In the standard setup, the screen is stored and recalled by simply pressing the STORE and the RECALL key, respectively.
Where the expansion memory option is provided, a desired memory number is set, then the corresponding screen is stored or recalled by pressing the STORE or RECALL key. In this case, the standard screen memory is numbered 0 and is handled just like the added memory option.

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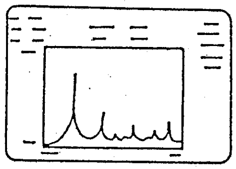
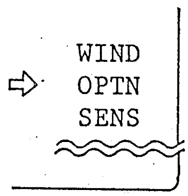
Notice that only screen memory No. 0 is available for ± calculations between screens.
The memory number is incremented by 1 every time the STORE or RECALL key is pressed. This means that where consecutive screen memory numbers are stored or recalled, there is no need to set each number.
Each screen memory area can be recalled only if it is stored.
Given a system reset, the FFT analyzer clears the entire screen memory (see 3.3 of this manual). In this state, no screen data can be recalled.

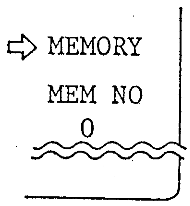
11.3.1 Storing Data in Screen Memory



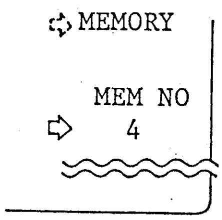
1) Get the target waveform displayed on the FFT analyzer's screen.



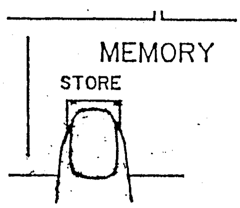
2) Position the MENU cursor to OPTN.



3) Press the ITEM key to have the MEMORY menu displayed.

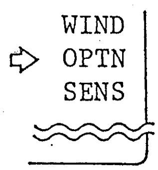


4) Press the NEXT key to position the ITEM cursor to the MEM NO item. Operate the ITEM key to get the number of the screen memory into which to store the waveform.

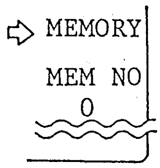


5) Press the STORE key in the MEMORY section of the panel, and the screen of 1) above will be stored in the screen memory whose number was set in 4).

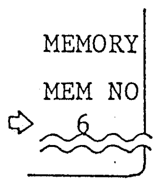
11.3.2 Recalling Data from Screen Memory



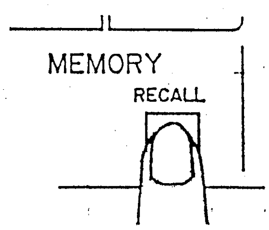
1) Press the MENU (▲▼) key to position the MENU cursor to OPTN.



2) Press the ITEM key to have the MEMORY menu displayed.



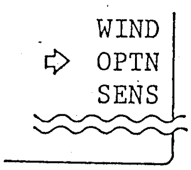
3) Press the NEXT key to position the ITEM cursor on the MEM NO item. Operate the ITEM key to get the number of the screen memory from which to recall data.



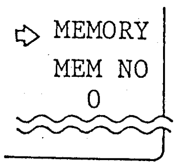
4) Press the RECALL key in the MEMORY section of the panel, and the data will be recalled from the screen memory whose number was set in 3) above.

Recall operation is not available if no data is stored in the screen memory.

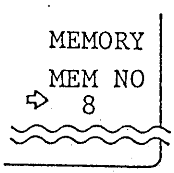
11.3.3 Setting the Protect Flag



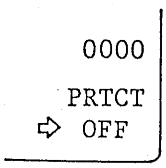
1) Press the MENU (▲▼) key to position the MENU cursor on OPTN.



2) Press the ITEM key to have the MEMORY menu displayed.



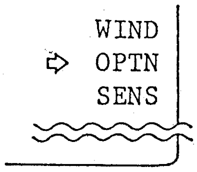
3) Press the NEXT key to position the ITEM cursor on the MEM NO item. Operate the ITEM key to get the number of the screen memory to be protected.



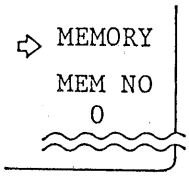
4) Press the NEXT key to position the ITEM cursor on the PRTCT (protect) item. Operate the ITEM key to set PRTCT to ON or OFF.

When PRTCT is set to OFF, data may be written in the memory which is not protected. When PRTCT is set to ON, it is impossible to write data in the memory. In the latter case, the STORE key in the MEMORY section is not operable.

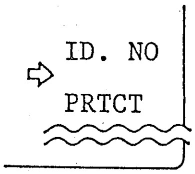
11.3.4 Input the ID Number



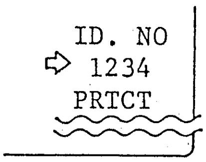
1) Position the MENU cursor to OPTN.



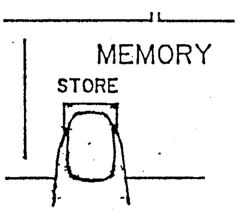
2) Press the ITEM key to get the MEMORY menu displayed.



3) Press the NEXT key to position the ITEM cursor on the ID.NO item. Now the ID number, which was displayed in 4 digits, disappears from the screen. The analyzer is ready to accept a new number. If no number needs to be input, press the NEXT key or COMP SET key.



4) Input a 4-digit number (each digit 0-9) using numeric keys on the panel. With 4 digits entered, the analyzer automatically leaves its input-ready state.



5) The ID number thus set up is stored at the same time as the corresponding screen is stored into memory by pressing the STORE key. That is, an ID number must always be set before the STORE key is pressed.

11.4 Three-dimensional Display

11.4.1 Outline

The three-dimensional display is a function for displaying spectrums in transition, as shown in Fig. 11.1. It accurately analyzes how the spectrums change. The three-dimensional display shows three types of data: instant data, average data, and screen memory data.
The items analyzed by the three-dimensional display are divided into the following three types: mag-spectrum, zoomed mag-spectrum, and 1/3-octave band analysis.
The number of displayed waveforms and their angles can be selected.
When the three dimensional display is ON, the number of screen memories decreases, because the function uses 12 screen memories for its operation area.

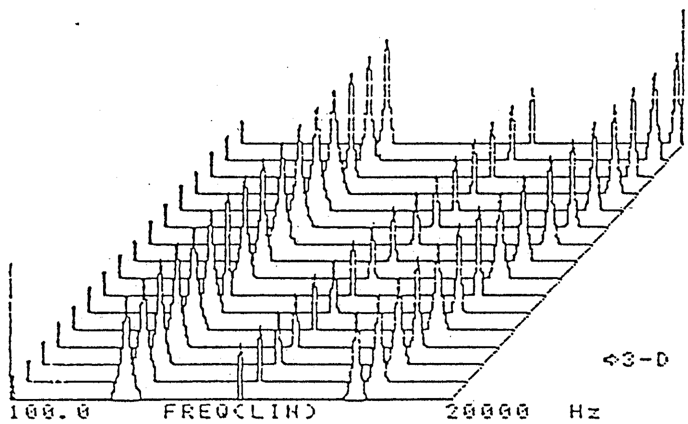


Fig. 11.1 Typical Display

11.4.2 Operation Procedure

(1) Displaying the MEMSET menu
Select the OPTN menu using the MENU (▲▼) keys in the SETUP section. Then, select the MEMSET menu using the ITEM (▲▼) keys. The MEMSET menu allows the three-dimensional display or zooming function, activated, or inhibited. The menu is displayed on the screen, as shown in Fig. 11.2.

```
   AVRG
   TRIG
   SCAL
   FUNC
   COMP
   WIND
→  OPTN
   SENS
   FREQ

 →MEMSET

  ZOOM
   OFF

  3-D
   OFF

  MEM=40
```

Fig. 11.2

(2) Activating the three-dimensional display
When the MEMSET menu is displayed, select item 3-D in the menu. Then set item 3-D to ON by pressing the ITEM (▲▼) keys. This activates the three-dimensional display operation. To inhibit the operation, set item 3-D to OFF by pressing the ITEM (▲▼) keys.
When item 3-D is switched to ON or OFF, the digits followed by MEM= are changed. The digits stand for the maximum value of screen memory numbers useable for screen

memory. For details, see the explanation of note (3) for the three-dimensional display (11.4.3).

(3) Displaying the 3-D menu

Position the cursor (→) to MEMSET. Select the 3-D menu using the ITEM (▲▼) keys. Figure 11.3 shows the contents of the 3-D menu.

```
→3-D

CONTRL
 STOP
M/VIEW
 VIEW
NO.
 00
ANGLE
 LOW2
LINE
 16
```

Fig. 11.3

(4) Setting the 3-D menu

The 3-D menu sets various parameters that are necessary for the three-dimensional display. These parameters are described below.

① CONTRL

This function activates the three-dimensional display. Although the CONTRL is set to STOP (and so the function is not executed) in Fig. 11.3, setting the CONTRL to START with the ITEM (▲▼) keys activates the three-dimensional display. The menu is not displayed on the screen while operating the three-dimensional display. To stop the operation, press the ITEM (▲▼) keys.

② M/VIEW

This function selects one of the following three methods for executing the three-dimensional display.

* VIEW

  VIEW updates the three-dimensional display when time data is read and the necessary operations are completed. The function usually displays instant data using the three-dimensional display.

* MEM

  MEM displays the contents of screen memory sequentially, using the three-dimensional display. The three-dimensional display starts at the screen memory number specified by "No.", and stops after displaying the memory corresponding to the last memory number. Note that the frequency range and sense range of the displayed data of memories are assumed to be equal to those of the data that was being displayed when the three-dimensional display started.

* AVRG

  AVRG updates data on the three-dimensional display when the average data is processed for the number of times set. AVRG displays the result of an average operation when the data is completely processed. To update data this way, set the RESTRT to ON in the AVRG menu. Then perform the average restart operation.

As mentioned, M/VIEW contains three methods to perform the three-dimensional display. The display is used to process instant data, memory data, and average data. It is advisable to display the data for each operation before activating the three-dimensional display.

③ NO.
When displaying the contents of screen memories using the three-dimensional display, the display starts from the memory number specified by "NO.". The three-dimensional display stops after displaying the contents that correspond to the memory number indicated by MEM= in the MEMSET menu.

④ ANGLE
ANGLE determines the display angles. The angles to be used for the three-dimensional display are divided into the following five types: LOW2, LOW1, MID, HI1, and HI2. They are measured from the X-axis on the display as follows: LOW2 is 15 degrees; LOW1 is 35 degrees; MID is 50 degrees; HI1 is 70 degrees; and HI2 is 90 degrees.

⑤ LINE
LINE determines the number of waveform lines in the three-dimensional display. The number of lines is selectable from 1 to 16.

(5) Stopping temporarily
When the CONTRL is switched from STOP to START, the three-dimensional display starts. During the three-dimensional display, the operation can be stopped temporarily by the following sequence: Press the HOLD/REL key in the TRIG section; then set the LED for hold to ON. When the hold is released, the three-dimensional display resumes.
When starting the three-dimensional display during a hold, waveforms do not appear on the screen. To display the waveforms, release the hold.

11.4.3 Notes on the Three-dimensional Display

(1) The three-dimensional display cannot be displayed in any of the following states:

① When displaying time waveforms, histograms, or phase spectrums.

② When the LED of the ON/OFF key in the COMP section is set to ON.

(2) Functions that cannot be used while executing the three-dimensional display:

① Display of time waveforms, histograms, or phase spectrums

② Comparator function

③ The following keys: MENU (▲▼), COMPSET, NEXT, FREQ, and SENSE keys in the SETUP section.

④ Storing and recalling functions for the screen memory

(3) Unusable screen memory

The three-dimensional display execution needs enough screen memory to display 12 screen data.

When the zoom operation is inhibited, the contents of 12 memories (29 to 40) are cleared up on executing the three-dimensional display. When the zoom operation is permitted, the contents of a certain number of memories (equal to the number of screen memories necessary for the zoom operation plus 12) are cleared upon executing the three-dimensional operation. The necessary screen memories are cleared in descending order (e.g. 40, 39, 38, ...). When the memories are cleared, their protect flags become nullified.

The maximum value of the memory numbers to be used for normal operation is displayed at the MEM= in the MEMSET menu.

For details, see explanation (3) in the notes for zoom, 11.5.7.

11.5 Zoom

11.5.1 Outline

The zoom can magnify a specified frequency 2 times, 4 times, 8 times, 16 times, or 32 times, and then analyze it. For example, the zoom magnifies peripheral spectrums at the frequency indicated by the cursor (e.g., the peak) using frequency resolution.
The frequency resolving power in the 20 KHz range is usually 100 Hz. So, when the zoom magnifies a frequency 32 times, the frequency can be analyzed with a resolving power of 100/32 = 3.125 Hz.
In addition to providing analysis with high resolving power, the zoom has another function. The zoom reads time waveforms of multiple frames continuously. It can analyze time waveforms or histograms at any desired point.

11.5.2 Operation Procedure

(1) Displaying the MEMSET menu
Select the OPTN menu using the MENU (▲▼) keys in the SETUP section. Then, select the MEMSET menu using the ITEM (▲▼) keys. Fig. 11.4 shows a typical MEMSET menu.

AVRG
TRIG
SCAL
FUNC
COMP
WIND
→ OPTN
SENS
FREQ

→MEMSET

ZOOM
OFF

3-D
OFF

MEM=40

Fig. 11.4

(2) Permitting zoom and setting the maximum magnification
Position the cursor (→) to ZOOM. Set the maximum magnification by pressing the ITEM (▲▼) keys. One of five kinds of magnification (i.e., 2, 4, 8, 16, or 32) can be selected. When the magnification is set, the zoom allows an object to be magnified up to the selected value. That is, the zoom can be performed within the setting magnification.
The zoom function clears parts of the screen memories for its operation area. Therefore, the number of available memories decreases. The number of screen memories to be used for the operation area is determined by the specified magnification. When the magnification is 2, 4, 8, 16, or 32, the number of screen memories is 4, 8, 12, 16, or 24, respectively. For details, see the explanation of (3) in the notes for zoom, 11.5.7.

The maximum memory number for screen memory is displayed at MEM= in the MEMSET menu. Figure 11.5 shows typical MEMSET menu.

```
   MEMSET

   ZOOM
→   ×32

   3-D
    OFF

   MEM=16
```

Fig. 11.5

(3) Displaying the ZOOM menu

Position the cursor (→) to MEMSET. Then display the ZOOM menu by using the ITEM (▲▼) keys. The ZOOM menu controls the zoom operation. Figure 11.6 shows the ZOOM menu.

```
ZOOM

CONTRL
 STOP

MAG.
 × 2
```

Fig. 11.6

(4) Setting the ZOOM menu

① CONTRL

Pressing the ITEM (▲▼) keys sets CONTRL to either START or STOP. Setting CONTRL to START starts the zoom operation. To set the center frequency, see item (5) below.

Setting CONTRL to STOP terminates the zoom operation. Then you can enter an operation other than zoom.

② MAG.

MAG. sets the magnification to operate the zoom. The magnification can be set within the maximum value determined in the MEMSET menu. For example, when the maximum magnification is set to 8 in the MEMSET menu, the magnification for MAG. can be 2 times, 4 times, or 8 times, all of which are within 8 times. The maximum magnification is set in the MEMSET menu to avoid decreasing the number of screen memories during the zoom operation.

(5) Setting the center frequency

① Setting the peak in center to operate the zoom

You can activate the zoom without a cursor on the screen. In this case, the zoom operates with the setting magnification, and the peak position appears at the center of the screen.

If a frequency on the left side of the screen is negative when the peak position is set at center, the center frequency is automatically modified to avoid having negative values.

If a frequency exceeds the frequency limit on the right side of the screen, the center frequency is automatically modified to avoid having excessive frequencies.

In both of the above cases, the peak position is consequently not displayed at the center of the screen.

When the zoom operation is completed, the menu that was seen before the zoom operation again appears on the screen.

② Specifying the center frequency by using the cursor

Display the cursor. Then move to the position you want displayed at the center of the screen. Next, execute the zoom.

If a frequency is negative on the left side of the screen, or if a frequency exceeds the frequency limit on the right side, the center frequency is automatically modified. In such cases, the frequency point specified with the cursor is not displayed at the center of the screen. The cursor then moves to the center of the screen and indicates the actual center frequency.

③ Shifting the screen during the zoom operation
The screen can be shifted from side to side during zoom operation. To shift the screen, get the cursor to disappear from the screen. Then press the (◀▶) keys in the CURSOR&FRAME section. The center frequency will change in steps equal to 1/200 of the frequency range (the frequency resolving power during non-zoom operation). The screen shifts accordingly. To shift the screen to the left, press the (◀) key. To shift the screen to the right, press the (▶) key.

11.5.3 Comparator Function

The comparator function can be executed during zoom operation. When the parameters for the comparator have been set during zoom operation and the comparator function set to ON, the comparator and zoom both activate. This function is available even when the zoom is not operated.

11.5.4 Typical Zoom Operation

As an example of how the zoom operates, a test signal spectrum will be magnified here.
As in Fig. 11.7, display a test signal spectrum. Then position the cursor at the 10.40 KHz spectrum, and execute the zoom operation with a magnification of 2.
The result of the zoom operation can be analyzed by using the zoom which magnifies the 10.40 KHz spectrum 2 times, as shown in Fig. 11.8.

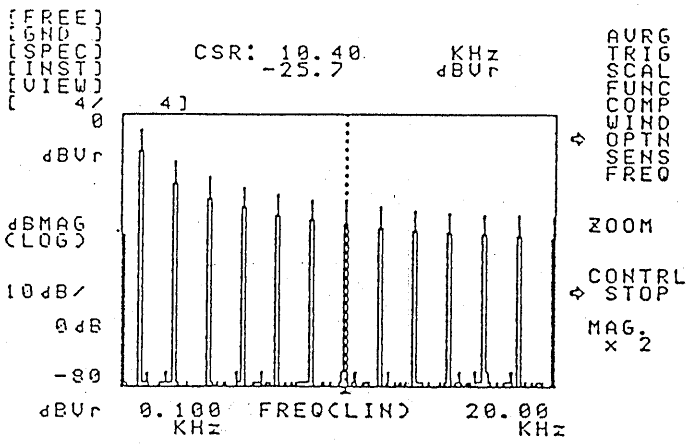


Fig. 11.7 Screen before the Zoom is Executed

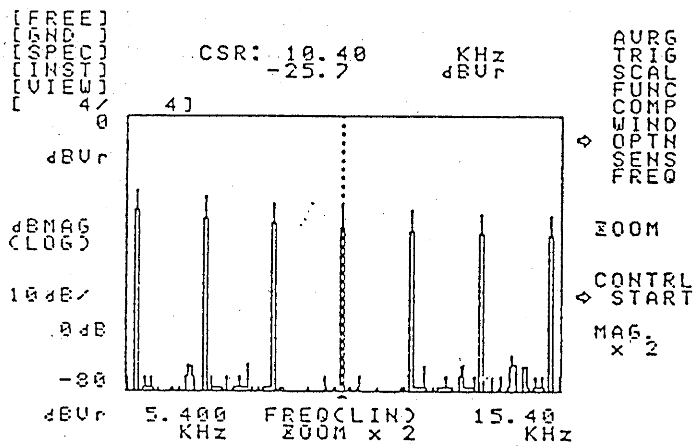


Fig. 11.8 Screen after the Zoom is Executed

11.5.5 Time Waveforms during Zoom Operation

(1) Outline

When operating the zoom, more time waveforms can be executed, because magnification of the zoom is greater. When magnification of the zoom is set to N, the number of time waveforms necessary for processing is N frames (i.e., 512 x N sampling data).

When the zoom is not operated, only the single frame of

87 3601

one time waveform is read and processed. When the zoom is operated, the number of frames of time waveforms equals the magnification of the zoom. They can be read continuously.
Therefore, any one of the frames can be selected to analyze the time waveform and histogram. The zoom is available as a transient memory function by which up to 32 frames of continuous time waveforms can be stored for later analysis.

(2) Typical operation

① Execute the zooming.

② Display the time waveforms.

③ Press the MENU (▲▼) keys to display the SCAL menu. Then set the TIME item to x 1.

④ Set the cursor to OFF. Then make the cursor disappear from the screen.

⑤ Press the (◀▶) keys in the CURSOR&FRAME section to display the time waveforms. Move them step-by-step, in units of 1/2 frame.
Continuous frames of time waveforms have their own frame numbers, which are determined as follows: when the zoom is magnified N times, the frames are numbered from 0 to N-1.
When the screen is shifted, the frame number is displayed left of center. For example, if the zoom is magnified 4 times, such indications as [0/4], [0./4], and [1/4], appear at the mid-left of the screen. The digit to the right of each slash [/] indicates the total number of frames (equal to the magnification of the zoom).
The digit to the left of slash [/] indicates the frame number of the time waveform being displayed, in units of one frame. A period [.] in the frame number stands for [.5]. For example, [2.] stands for [2.5].

This means that the latter half of frame No. 2 and the first half of frame No. 3 are both displayed on the screen.
The latter half of one frame is usually contiguous with the first half of the following frame. However, as shown in Fig. 11.9, when the frame number is [3./4], the latter half of the last frame has no next frame to continue onto.

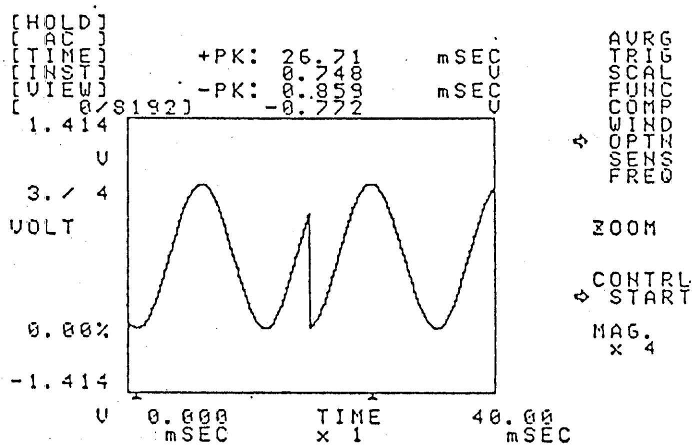


Fig. 11.9

11.5.6 Operation of the TRIG Section

(1) Free Run

Free Run during Zooming, in contrast with non-zoom operation, does not execute overlap processing. Free Run always reads the time waveforms for the number of frames necessary for zoom magnification. After executing the desired processing, Free Run reads the new time waveforms necessary for the next processing.

(2) Armed, and Auto Armed

Armed and Auto Armed perform the same operations as during non-zoom operation. However, the trigger position executes operations different from those during non-zooming.

As mentioned above, when the zoom is magnified N times, the zooming executes N frames (512 x N sampling data). In this case, the trigger position is determined to be N x the value set in the TRIG menu.
For example, when the zoom is magnified 8 times and the trigger position is set to PRE100, the number of sampling data is 4096. The actual trigger position is processed as PRE800. In this example, the 800th data item of the 4096 sampling data is processed as the trigger position.

11.5.7 Notes on Zooming

(1) Zooming cannot be executed in any of the following states:

① When executing the average operation.
② When executing the 1/3-octave band analysis.
③ When displaying the phase spectrum.
④ When displaying logarithms on the X-axis.
⑤ When performing differentiation, integration, addition, or subtraction.
⑥ When displaying the harmonic cursor.
⑦ When holding
⑧ When the unit used for the X-axis is set to ORD for cursor read-out.

(2) Functions inhibited that are during zooming:

① 1/3-octave band analysis
② Phase spectrum display
③ Display of logarithms on the X-axis
④ Differentiation, integration, addition, and subtraction
⑤ Display of the harmonic cursor
⑥ Switching the units of the X-axis to ORD for cursor read-out
⑦ Window change, filter ON/OFF, or change of zooming magnification during a hold

(3) Unusable screen memory

Regardless of the magnification used for the operation, activating the zooming clears parts of the screen memories according to the magnification set in the MEMSET menu. The cleared screen memories are used for zooming. When the magnification is set to 2, 4, 8, 16, or 32 times in the MEMSET menu, the zooming operation needs memories 4, 8, 12, 16, or 24 memories, respectively.

When the zooming operation acquires memories, it ignores protect flags. The memories that are cleared to safety magnification needs are in descending order (40, 39, 38 ...).

When the three-dimensional display and zooming operation are both permitted, the number of memories required for the operation area is equal to the sum of the memories necessary for each of these two operations.

The MEM= item in the MEMSET menu displays the maximum screen memory number available for the user area. Table 11.1 lists the numbers of the memories allocated for the operation area and the screen memory, according to the various zooming magnifications, and whether the three-dimensional display is ON or OFF.

Table 11.1 Allocation of Memory for Screen and for Operations

ZOOM	MEMSET menu set			
	3-D OFF		3-D ON	
	Screen memory	Memory for operation area	Screen memory	Memory for operation area
OFF	0 - 40		0 - 28	29 - 40
x2	0 - 36	37 - 40	0 - 24	25 - 40
x4	0 - 32	33 - 40	0 - 20	21 - 40
x8	0 - 28	29 - 40	0 - 16	17 - 40
x16	0 - 24	25 - 40	0 - 12	13 - 40
x32	0 - 16	17 - 40	0 - 4	5 - 40

Note: The contents of the memories for the operation area are cleared when the three-dimensional display or the zooming activates. Therefore, when the 3-D item in the MEMSET menu is switched ON/OFF, or when the magnification in the ZOOM item is changed, the contents are not cleared from any memory having a number greater than the number specified in the MEM= item.

(4) Displaying average data

Average data can be displayed by pressing the AVG/INST key during the zoom operation. When displayed, the average data is regarded as having the same magnification and center frequency as the zoom operation being executed. Keep this in mind when the original magnification and center frequency of the average data differ from those of the zooming.

11.6 1/3-octave Band Analysis

11.6.1 Outline

The analyzer can perform a 1/3-octave band analysis, which involves 29 1/3-octave bands from spectrums analyzed by the FFT. The analyzing range is subdivided into LOW and HIGH ranges. The LOW range refers to a center frequency from 1 Hz to 630 Hz, while the HIGH range center frequency is from 20 Hz to 12.5 KHz. Each of the ranges contains 29 1/3-octave bands. The 1/3 octave band analysis uses 29 1/3-octave bands taken from 600 spectral lines (which are analyzed by switching three frequency ranges).

11.6.2 Specifications

Filter characteristics:	ANSI CLASS III Standard. Figure 11.10 shows the filter specifications. For band number, center frequency, LOW range, and HIGH range, see Tables 11.2 and 11.3.
Frequency correction characteristics:	"A" Weighting. ANSI standard. See Fig. 11.11.
Analizing time:	LOW range: 30 seconds (approximately) HIGH range: 5 seconds (approximately)

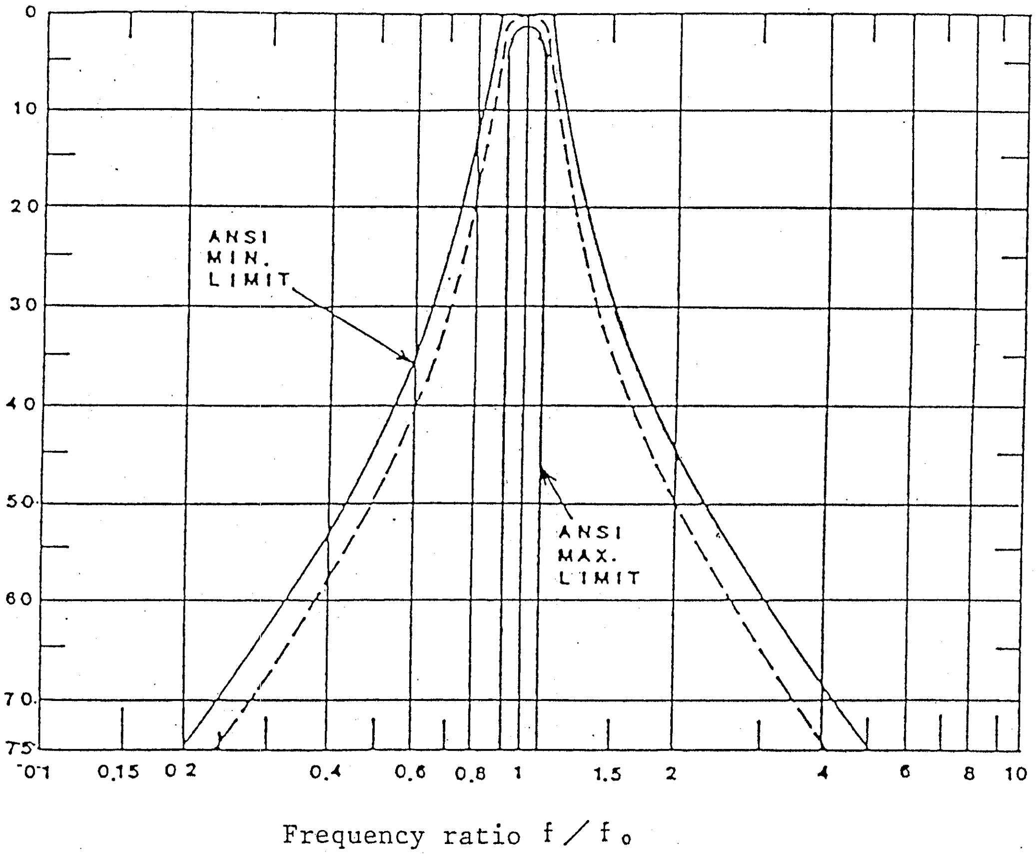


Fig. 11.10 Filter Characteristics (the dashed line shows the characteristics of the analyzer)

(f_0 stands for the center frequency)

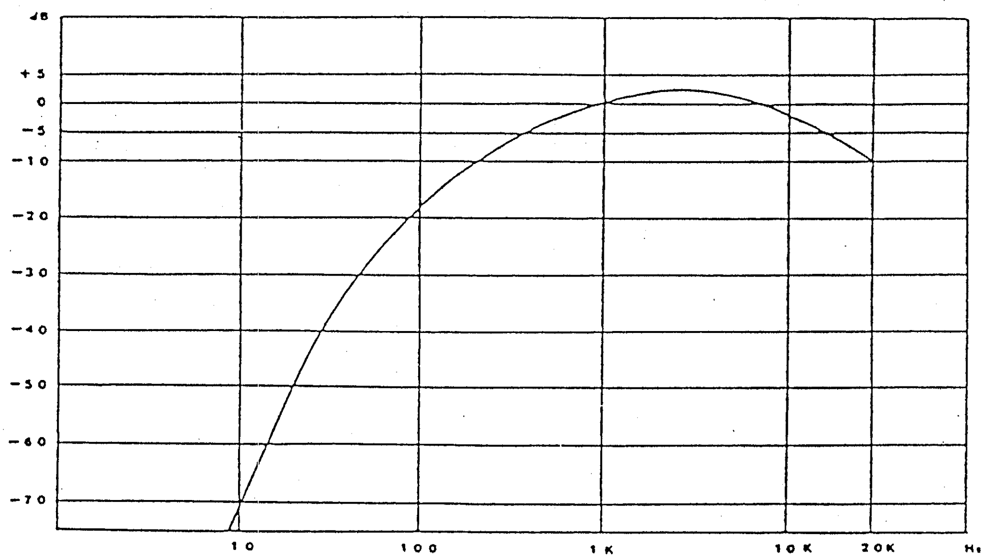


Fig. 11.11 Frequency Correction Characteristics ("A" Weighting)

Table 11.2 LOW Range

Band No.	Center Frequency (Hz)	"A" Weighting (dB)
0	1	-75.0
1	1.25	-75.0
2	1.6	-75.0
3	2	-75.0
4	2.5	-75.0
5	3.15	-75.0
6	4	-75.0
7	5	-75.0
8	6.3	-75.0
9	8	-75.0
10	10	-70.4
11	12.5	-63.4
12	16	-56.7
13	20	-50.5
14	25	-44.7
15	31.5	-39.4
16	40	-34.6
17	50	-30.2
18	63	-26.2
19	80	-22.5
20	100	-19.1
21	125	-16.1
22	160	-13.4
23	200	-10.9
24	250	-8.6
25	315	-6.6
26	400	-4.8
27	500	-3.2
28	630	-1.9

Table 11.3 HIGH Range

Band No.	Center Frequency (Hz)	"A" Weighting (dB)
13	20	-50.5
14	25	-44.7
15	31.5	-39.4
16	40	-34.6
17	50	-30.2
18	63	-26.2
19	80	-22.5
20	100	-19.1
21	125	-16.1
22	160	-13.4
23	200	-10.9
24	250	-8.6
25	315	-6.6
26	400	-4.8
27	500	-3.2
28	630	-1.9
29	800	-0.8
30	1 K	0
31	1.25	0.6
32	1.6	1.0
33	2	1.2
34	2.5	1.3
35	3.15	1.2
36	4	1.0
37	5	0.5
38	6.3	-0.1
39	8	-1.1
40	10	-2.5
41	12.5	-4.3

11.6.3 Operation of 1/3-octave Band Analysis

(1) Displaying the OCTAVE menu

Select the OPTN menu using the MENU (▲▼) keys in the SETUP section. Then, press the ITEM (▲▼) keys to select the OCTAVE menu.

```
   AVRG
   TRIG
   SCAL
   FUNC
   COMP
   WIND
→  OPTN
   SENS
   FREQ

→OCTAVE

 CONTRL
  STOP

 A-WGT
  OFF

 RANGE
  LOW
```

Fig. 11.12

(2) Setting the OCTAVE menu

① RANGE

RANGE sets the LOW or HIGH range. The center frequency in the LOW range is from 1 Hz to 630 Hz (band numbers 0 to 28). The center frequency in the HIGH range is from 20 Hz to 12.5 KHz (band numbers 13 to 41).

② A-WGT

A-WGT sets the frequency correction characteristics to the "A" Weighting. To use the "A" Weighting, set

A-WGT to ON; otherwise, set A-WGT to OFF.

③ CONTRL

CONTRL starts and stops the 1/3-octave band analysis. To start the 1/3-octave analysis, display magspectrums on the screen; then set CONTRL to START. To stop the 1/3-octave band analysis, set CONTRL to STOP.

When the 1/3-octave band analysis stops, the frequency range is automatically set to what it was just before the 1/3-octave band analysis was executed.

④ Change of set items during operation

A-WGT and RANGE items can be changed during 1/3-octave band analysis execution. After an item is changed, the data of the 1/3-octave analysis display still include the previous item (i.e., the display is incorrect). The updated item will appear the next time the 1/3-octave data is displayed.

(3) Example of 1/3-octave band analysis display

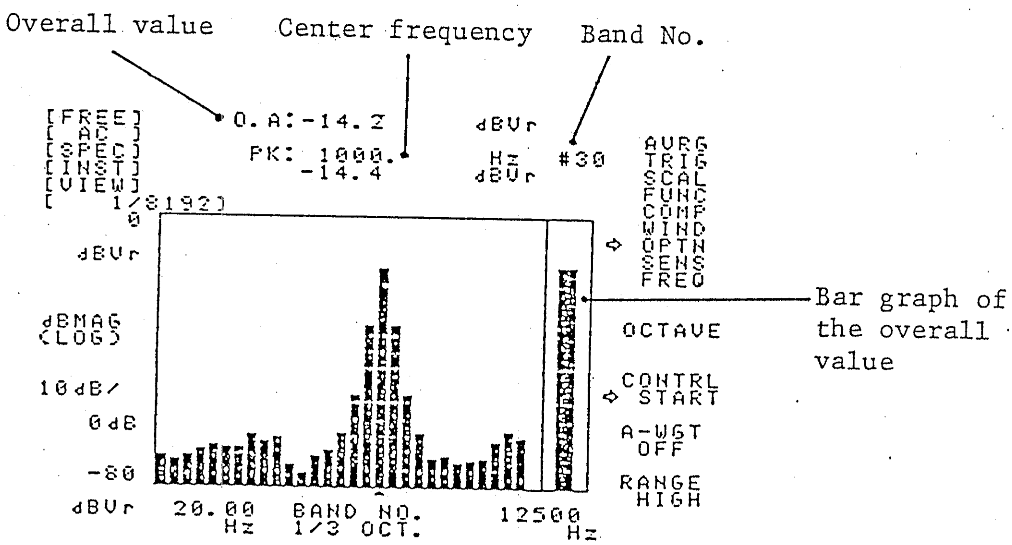


Fig. 11.13 Typical 1/3-octave Analysis Display

① Overall value
To display the overall value, select the FUNC menu. Then set the OV. All item to ON. The overall value is displayed in the upper part of the screen (Bar graph is always at the right side of the screen).

② Cursor
The cursor moves in units of one band when you press the (◀▶) keys. When data is read out, the center frequency of the band, the band number (#), and the decibel level are displayed on the screen. When the cursor is set to OFF, the read-out data indicates the peak of the center frequency, the band number, and the decibel level.
The 1/3-octave band analysis takes a comparatively long time. Therefore, the read-out data will be displayed late when the cursor is moved.
When the cursor matches the ▲ mark displayed under the cursor position, the correct read-out data is displayed on the screen. Due to the reason mentioned above, the read-out data is displayed late when the cursor is turned ON/OFF.

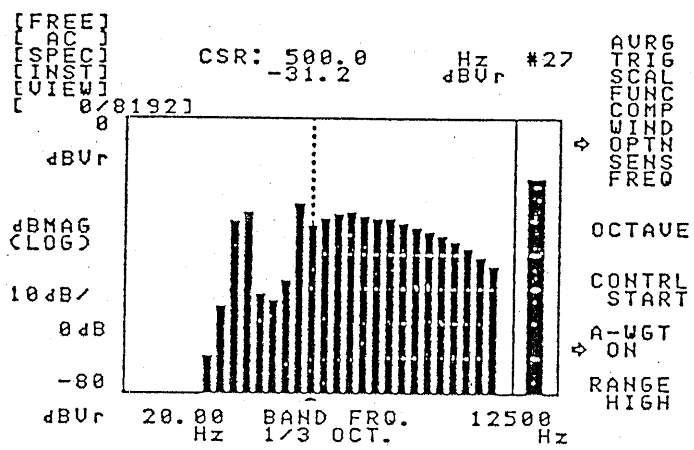


Fig. 11.14 Typical Cursor Display

11.6.4 Frequency Correction Characteristics

The psophometric value should be closest to the value obtained by human senses. Therefore, IEC, JIS, and other groups established a standard of frequency correction called "A" Weighting (see Fig. 11.11).
The "A" Weighting of the analyzer perform such correction in accordance with the procedures of an analog analyzer. That is, the analyzer corrects spectrum data according to frequency correction specified by the "A" Weighting and then uses the result in the 1/3-octave band analysis.
The IEC standard contains values ranging from 10 Hz to 20 KHz. The analyzer uses the value read from data shown in Fig. 11.11 as the correction value if the correction value is 10 Hz or less. However, when the correction value is -75 dB or less (less than approximately 8 Hz), the analyzer uses -75 dB as the correction value.

11.6.5 1/3-octave Band

Human sense of hearing is close to logarithmic in its ability to measure frequency. When noise is measured, its frequency is divided into one-octave band units to indicate the sound pressure (decibel level). This sound pressure is called the "octave band level". Whenever the relationship between frequency f_1 and f_2 is $f_2 = 2f_1$, the band between f_1 and f_2 is called an octave band.
The frequency f_0, defined as $f_0 = \sqrt{f_1 \cdot f_2}$, is called the "center frequency" of the octave band. In this case, the relationships between f_0, f_1, and f_2 are as follows:

$$f_0 = \sqrt{2} \cdot f_1 = f_2/\sqrt{2}$$

The international standard for the center frequency is 1 KHz. Therefore, the center frequencies for the analyzer are: ...63, 125, 250, 500 Hz, 1, 2, 4, 8 KHz .... Each octave band contains its own octave filter (band pass filter). The result

output by such a filter is an octave band level. When the octave band levels are placed end-to-end, they are called an "octave band spectrum".
The analysis method mentioned above is called "1/1-octave analysis". Another method, which analyzes in more detail, is 1/3-octave analysis. In 1/3-octave analysis, the relationships between f_0, f_1, and f_2 are:

$$f_2 = \sqrt[3]{2} \cdot f_1$$

$$f_0 = \sqrt[6]{2} \cdot f_1 = f_2/\sqrt[6]{2}$$

The center frequency in each band is listed in Tables 11.2 and 11.3. The frequency characteristics of a 1/1-octave band are divided into three bands by 1/3-octave band analysis.

11.6.6 Method of Testing with the 1/3-octave Band

One of the testing methods that uses the 1/3-octave band is performed by inputting white noise. The level from one 1/3-octave band to the next increases by 1 dB because each band increase in width by a factor of $\sqrt[3]{2}$.
Figure 11.15 shows the result of a 1/3-octave band analysis in which averaging was executed 64 times after inputting white noise to the analyzer.

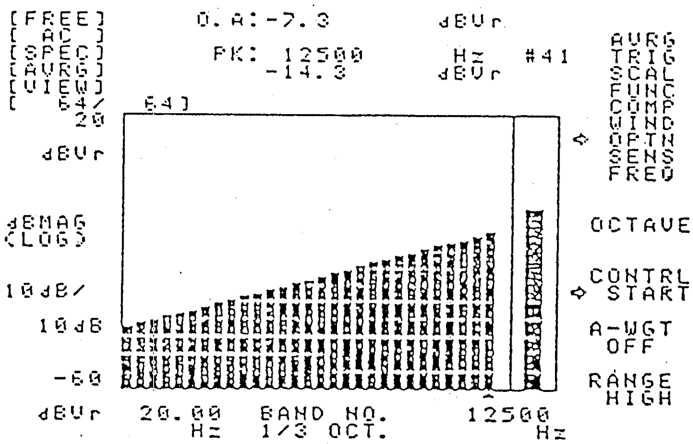


Fig. 11.15

11.6.7 Calibration (direct reading of the sound pressure by using the EU function)

Typically, calibration with a sound level meter is done as follows. Input a calibration signal from the sound level meter to the analyzer, and execute 1/3-octave band analysis. To display the overall value, set the range to HIGH, and set the "A" Weighting to OFF. For example, assume that the result of the analysis is as follows: the sound level meter reads 84 dB as shown in Fig. 11.16; and the overall value of the analyzer is -10.0 dB, as shown in Fig. 11.17.

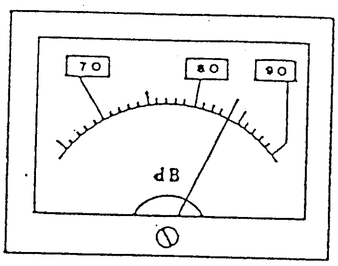


Fig. 11.16

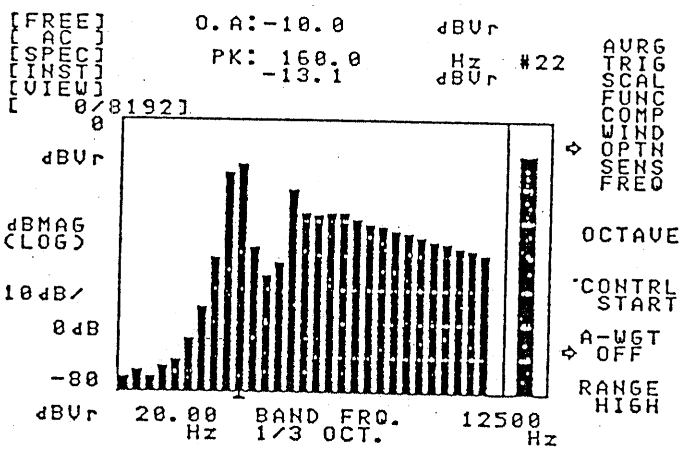


Fig. 11.17

Next, enter the EU value so that the overall value of the analyzer equals the value read by the sound level meter. To enter an EU value, see Section 8.4 ("Inputting an Engineering Unit"). The EU value to be input can be calculated as follows:

(overall value of analyzer) - (value read by sound level meter)

In this example, the calculation is:

(-10.0) - (84) = -94.0

Following the procedure shown in Fig. 11.18, we enter -94.0 for the EU value.

```
 SCALE
  OFF
0dBEU=
-094.0
   dBV
```

Fig. 11.18

After you enter the EU value, set the SCALE item to SCL in order to display the data on the analyzer and cause it calibrated. After calibration, the value displayed on the analyzer can be used as the actual level of sound pressure.
Before you measure the sound pressure level (after switching the measurement range of the sound level meter), you should correct the data. The actual sound pressure level can be calculated as follows: Find the increase in the range by subtracting the range at the time of calibration from the range after switching. Then, add this increase to the value indicated by the analyzer.
For example, when the analyzer calibrates based on 90 dB read by the sound level meter, and the measurement range after switching is 100 dB, the increase is:

100 - 90 = 10 (dB)

Then, add 10 dB to each value displayed by the analyzer. When the overall value of the analyzer is 85 dB EU, the actual sound pressure level is:

85 + 10 = 95 (dB EU)

Notice that both the sound level meter and the analyzer do not

need to execute frequency correction characteristics concurrently.
If the sound level meter executes a correction according to the "A" Weighting, the sound level meter outputs corrected signals. Therefore, the analyzer's output will be corrected with "A" Weighting, even without its executing the "A" Weighting correction.

11.6.8 Averaging

The 1/3-octave band analysis performs averaging. The menu for averaging is the same as during spectrum operation. Set DOMAIN to SPEC. If DOMAIN is set to TIME or HIST, averaging by 1/3-octave band analysis cannot be executed.
The averaging can be activated after executing 1/3-octave band analysis. Set the AVG/INST key to AVG (set its LED to ON) to display the result of averaging done by 1/3-octave band analysis.
When the averaging is being executed during the execution of 1/3-octave band analysis, the averaging will stop if the 1/3-octave band analysis is stopped. When the averaging is being executed during an operation other than 1/3-octave band analysis (or during an interrupt), the averaging will be forced to stop when 1/3-octave band analysis is executed.

11.6.9 Notes on 1/3-octave Band Analysis

(1) The 1/3-octave analysis cannot be executed in any of the following states:

① When executing zooming.
② When the comparator function is set to ON.
③ When displaying the harmonic cursor.
④ When performing differentiation, integration, addition, or subtraction.
⑤ When displaying the phase spectrum.
⑥ When displaying logarithms on the X-axis.

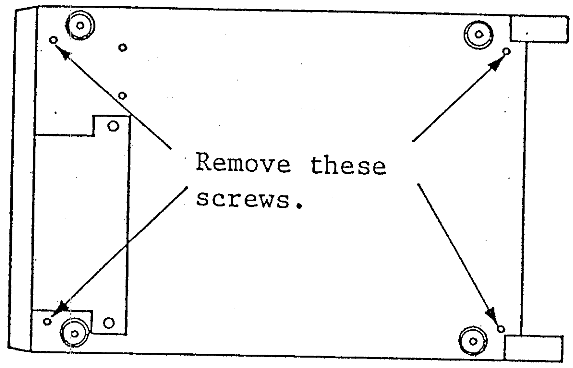
(2) Function of the TRIG section
When 1/3-octave band analysis is activated during armed or auto armed operation, the trigger operation is set to Free Run. The 1/3-octave band analysis is always executed in Free Run (set automatically).

(3) Frequency range to be used
The HIGH range calculates the spectrum by switching between the 3 types of frequency range in the order: 200 Hz, 2 KHz, and 20 KHz. Then, the HIGH range compiles the result of the 1/3-octave analysis.
The LOW range compiles the result by switching the three types of frequency range in the order: 10 Hz, 100 Hz, and 1 KHz
Note that the following are not malfunctions when 1/3-octave band analysis activates or completes:
1) Spectrum is displayed temporarily on the screen.
2) Key access takes a long time.

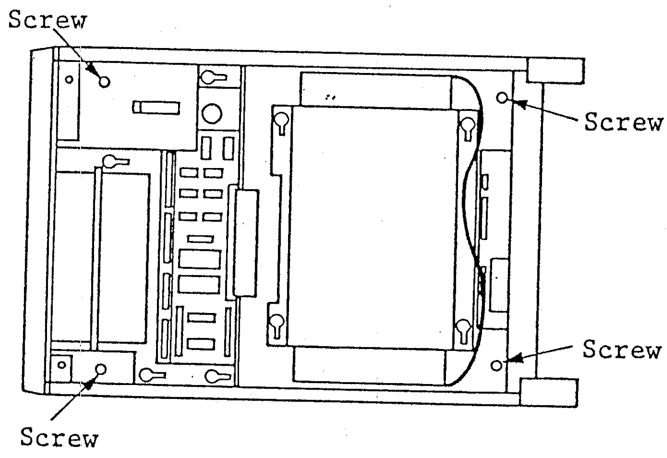
CHAPTER 12. INSTALLING THE OPTIONS (BU01, PU01, BP01-FAE)

12.1 Installing the Unit

(1) Position the unit upside down, remove four screws from the corners, and the bottom cover will be detached.



(2) Position the FAE2000 FFT Analyzer upside down. With the unit held upside down, place it onto the Analyzer so that the analyzer's legs will be held in the holes of the unit. Secure the Analyzer to the unit by tightening four screws.



(3) Mount and screw the bottom cover of the unit.

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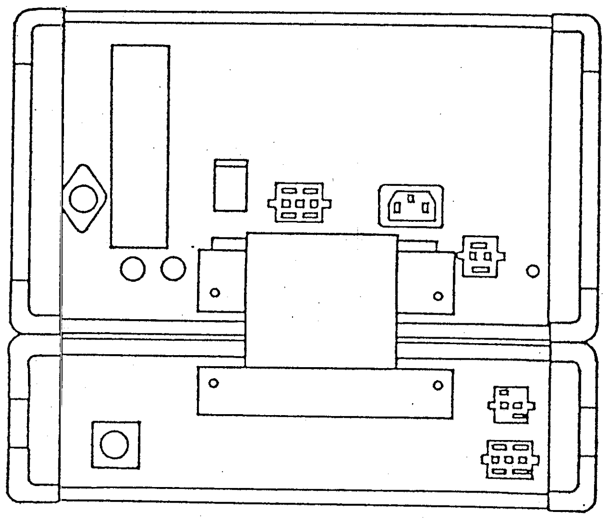
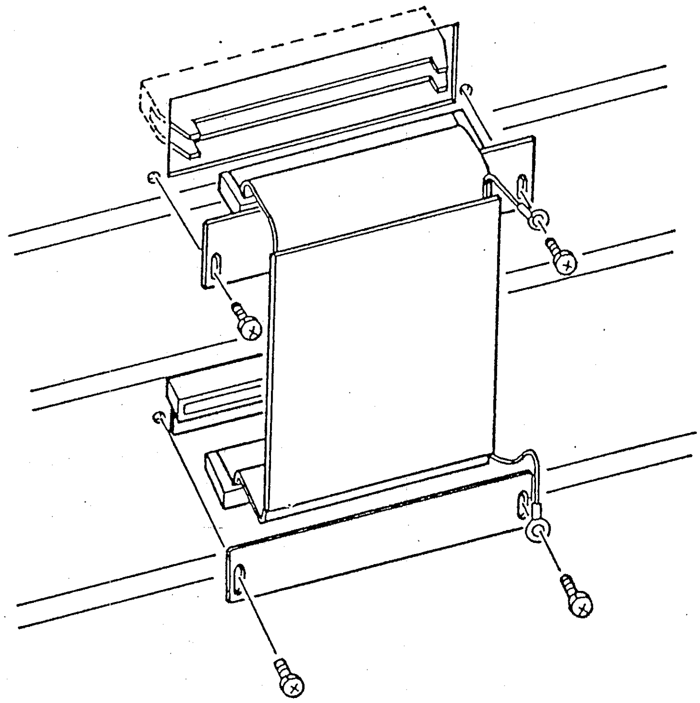
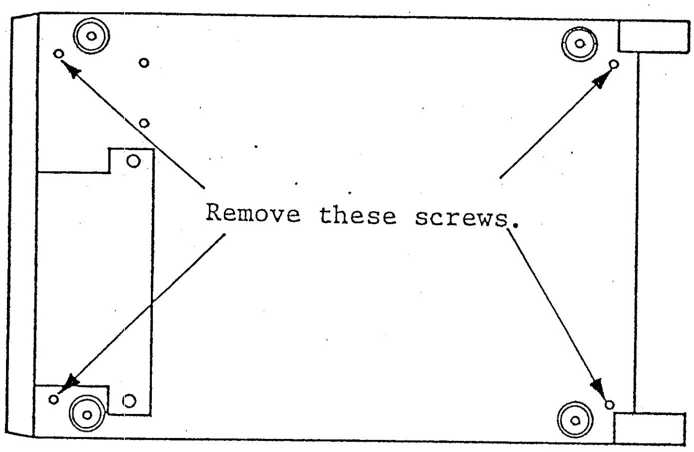
(4) Connect the bus cable between the FAE2000 FFT Analyzer and the printer as illustrated. (The cable is not needed where the BU01-FAE battery unit is installed.) Connect the DC power supply and printer power supply using the furnished cables.



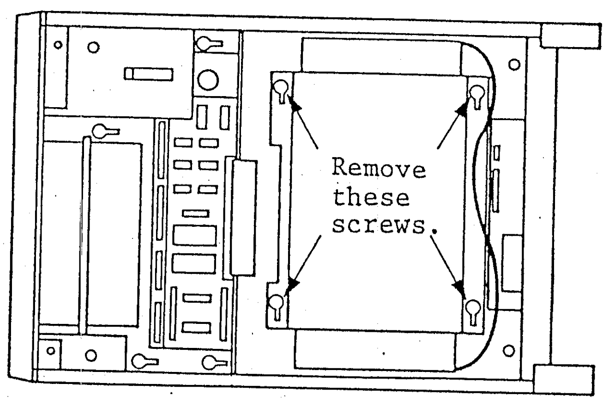


12.2 Replacing the Battery
(in BU01, BP01-FAE battery unit or battery printer unit)

(1) Position the FAE2000 FFT Analyzer (with battery unit/ battery printer unit) upside down. Remove four screws from the corner, and the bottom cover will be detached.



(2) Loosen screws on the battery fixture, shift the fixture sideways, and it will be detached. Disconnect the matenlock connectors from the battery, and the battery will be removed. When installing a new battery, reverse the above steps.



CHAPTER 13. CHARGING THE BUILT-IN BATTERY

13.1 Charging the Battery with the BC01-FAE

(1) Connect the BC01-FAE to an AC power source.

(2) Connect the charging cable between "OUTPUT A" of the BC01-FAE and "BATTERY CHARGER" of the FAE2000 (Fig. 13.1).

(3) Set the "OUTPUT SELECT" switch of the BC01-FAE to "A".

(4) Set the POWER switch of the BC01-FAE to ON, and LED "POWER" will light on the BC01-FAE and LED "CHARGER" will light on the battery unit.

(5) The status of charging is shown by how the "OUTPUT A" LED of the BC01-FAE lights. The LED lights when charging is started, blinks when the battery is 80% charged, and goes off when the battery is fully charged.

LED "OUTPUT A"	Charging status	Charging time	Degree of charging
Glowing	Charging under way	About 4 hours (with completely discharged battery)	0 - 80%
Blinking	Joggle charging under way	About 2 hours	80 - 100%
Turned off	Charging completed	–	100%

Note 1 : The FAE2000 may operate from an AC power source while the battery is being charged.

Note 2 : When the "OUTPUT SELECT" switch is set to "B" on the BC01-FAE, the battery proper may be taken out and charged individually. The charging status is monitored in the same manner as with the switch set to "A".

Note 3 : The "CHARGE" indicator lamp on the battery unit lights whenever the unit is connected to the BC01-FAE and the latter is turned on. At this time, the FAE2000 cannot operate on battery.

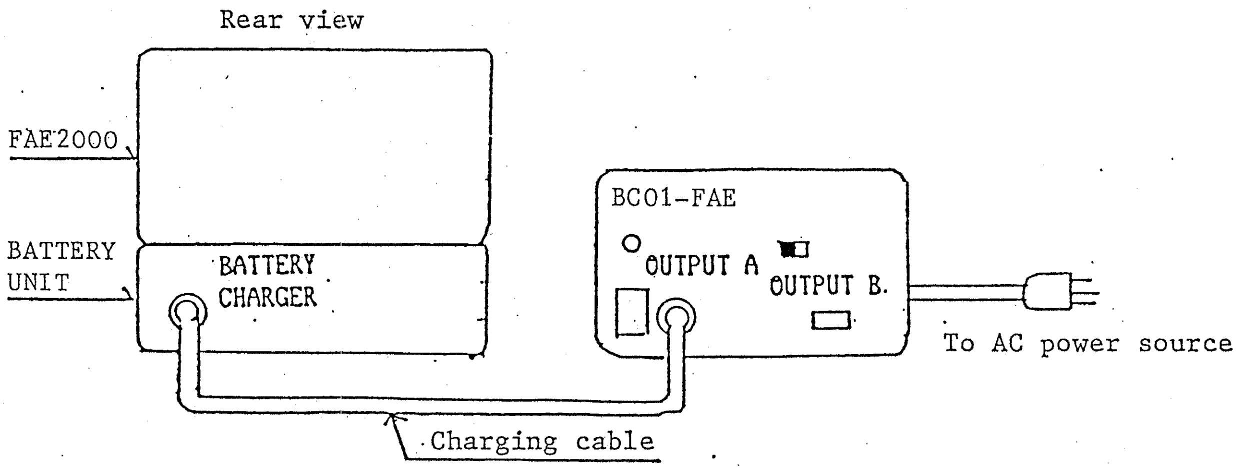


Fig. 13.1 Interconnections for Charging

13.2 Notes on Handling the Battery

When the FFT Analyzer is not operated on battery, charge the battery none the less about every 3 months. Do not leave the battery discharged, or the electrodes in the battery will become covered with film, sometimes disabling the battery unit.

In particular, note the following:

(1) Be sure to charge the battery about every 3 months, or the battery will begin to deteriorate in performance. After using the battery, recharge it as soon as possible. Store the battery fully charged.

(2) In battery-powered operation, the battery function stops after the "LOW BATT" indicator lights. Then the POWER switch may be left on, or the battery may be left discharged for a long time. In such cases, attempts to charge the battery with the BC01-FAE battery charger fail promptly when they are made. To remedy the situation, keep the POWER switch of the battery charger on for about 80 hours after the charging operation is stopped. This will let a very small current flow and charge the battery.

(3) When the battery is charged under the conditions above, the initial capacity may not be restored.

(4) Do not disassemble the battery. In case sulfuric acid spills onto the skin or clothes from a damaged battery, rinse off the chemical immediately with water. If acid gets into the eye, immediately rinse it with large quantities of water and consult a doctor as soon as possible.

(5) Do not incinerate the battery.

CHAPTER 14. REPLACING THE THERMOSENSITIVE PAPER

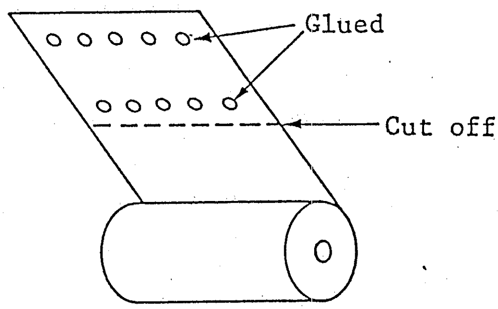


Fig. 14.1

1) Prepare the proprietary thermosensitive paper WP:PP-123. Cut off the paper tip crosswise at a position beyond the glued part, towards the roll core (Fig. 14.1).

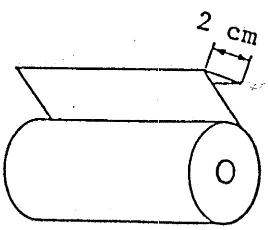


Fig. 14.2

2) Fold back a 2 cm-wide portion of paper tip outward (Fig. 14.2).

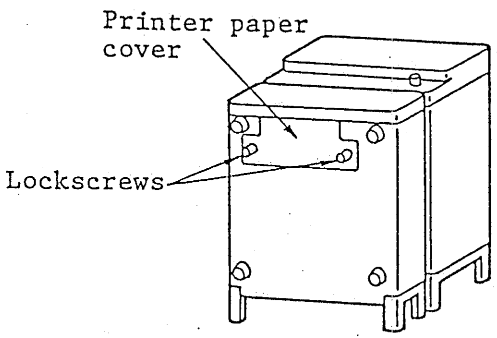


Fig. 14.3

3) Position the FAE2000 upright. Loosen by hand two lock screws that secure the printer's paper cover. Detach the cover (Fig. 14.3).

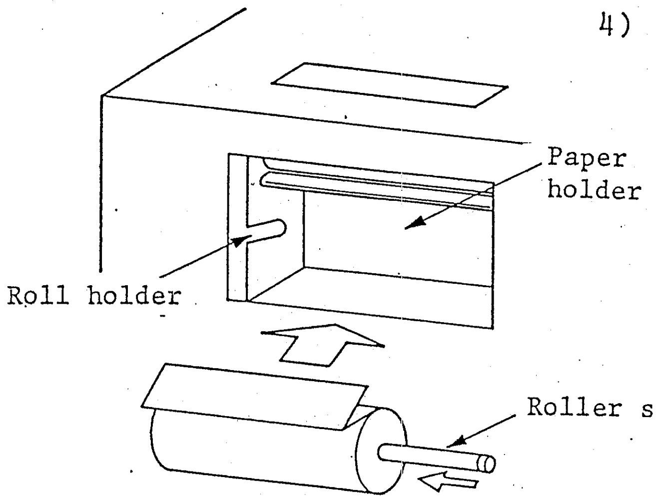


Fig. 14.4

4) Take the roll shaft out of the paper roll holder. Insert the shaft into the new roll. Put the roll into the holder (orientation indicated in Fig. 14.4).

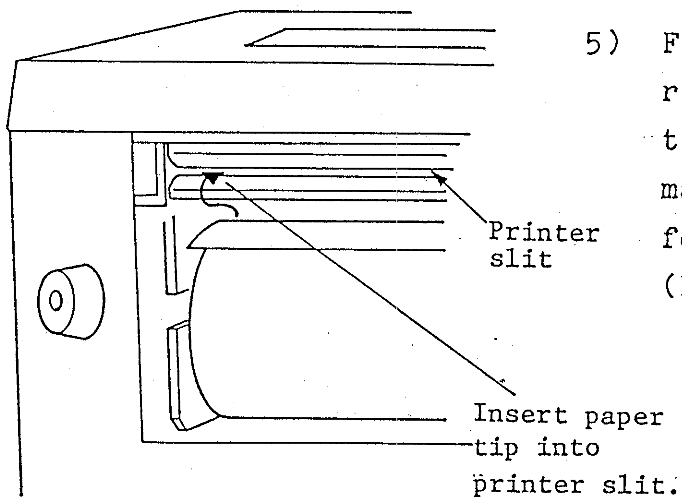


Fig. 14.5

5) Feed a sufficient amount of roll paper tip into the printer's slot. The insertion is made easy by holding the folded portion at both ends (Fig. 14.5).

6) Press the FEED key. Check to see if the paper appears from the front panel of the printer. Feed the paper for another 20 cm (approx.), and check that the roll paper is free of slack or crosswise displacement.

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7) Mount the paper cover on the printer.

Note 1 : An end mark, about 40 cm long, appears at the end of the thermosensitive paper.

Note 2 : Store the paper at a temperature less than 40°C, at less than 90% relative humidity (storage at higher temperatures may cause discoloration). The average storage temperature should be 25°C, with less than 65% relative humidity.

CHAPTER 15. OPERATION FROM AN EXTERNAL DC POWER SUPPLY

(1) What is needed

1) DC power supply
Output rating : 11 - 15 V, 8 A or more
2) Furnished DC power cable
KO : 350A-3S200

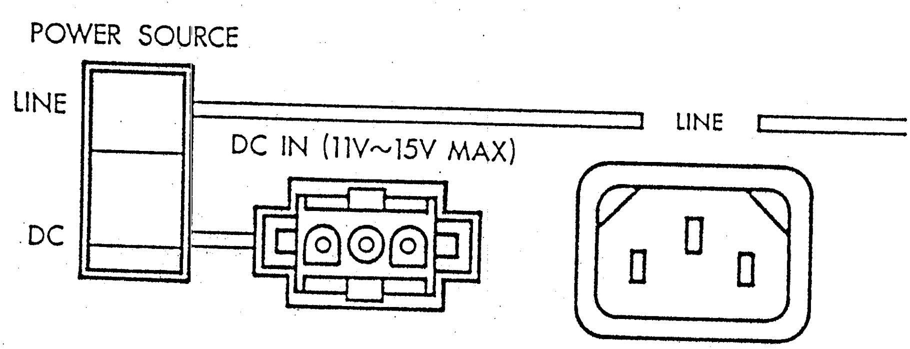
(2) Connecting procedure

1) Connect the furnished DC power cable (KO: 350A-3S200) as indicated below.

Pin No.	Power output	
1	+	DC 11 - 15 V
2	-	
3	Case ground	

Use pin 3 for grounding the case.

2) Connect the DC power cable to "DC IN" of the FAE2000's rear panel.
3) Set the "POWER SOURCE" switch to DC.
4) Turn on the external DC power supply.
5) Throw the POWER switch of the FAE2000.



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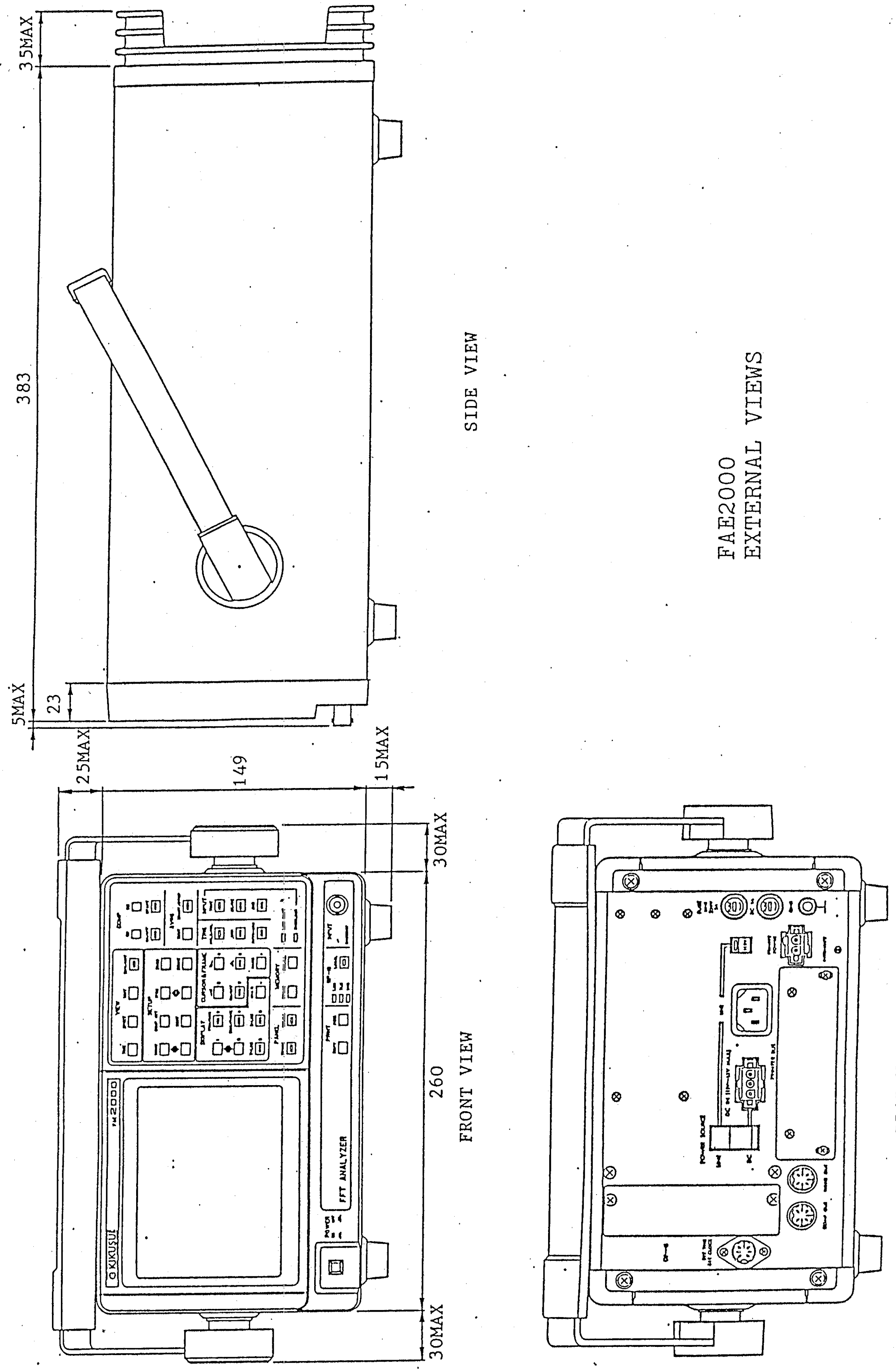
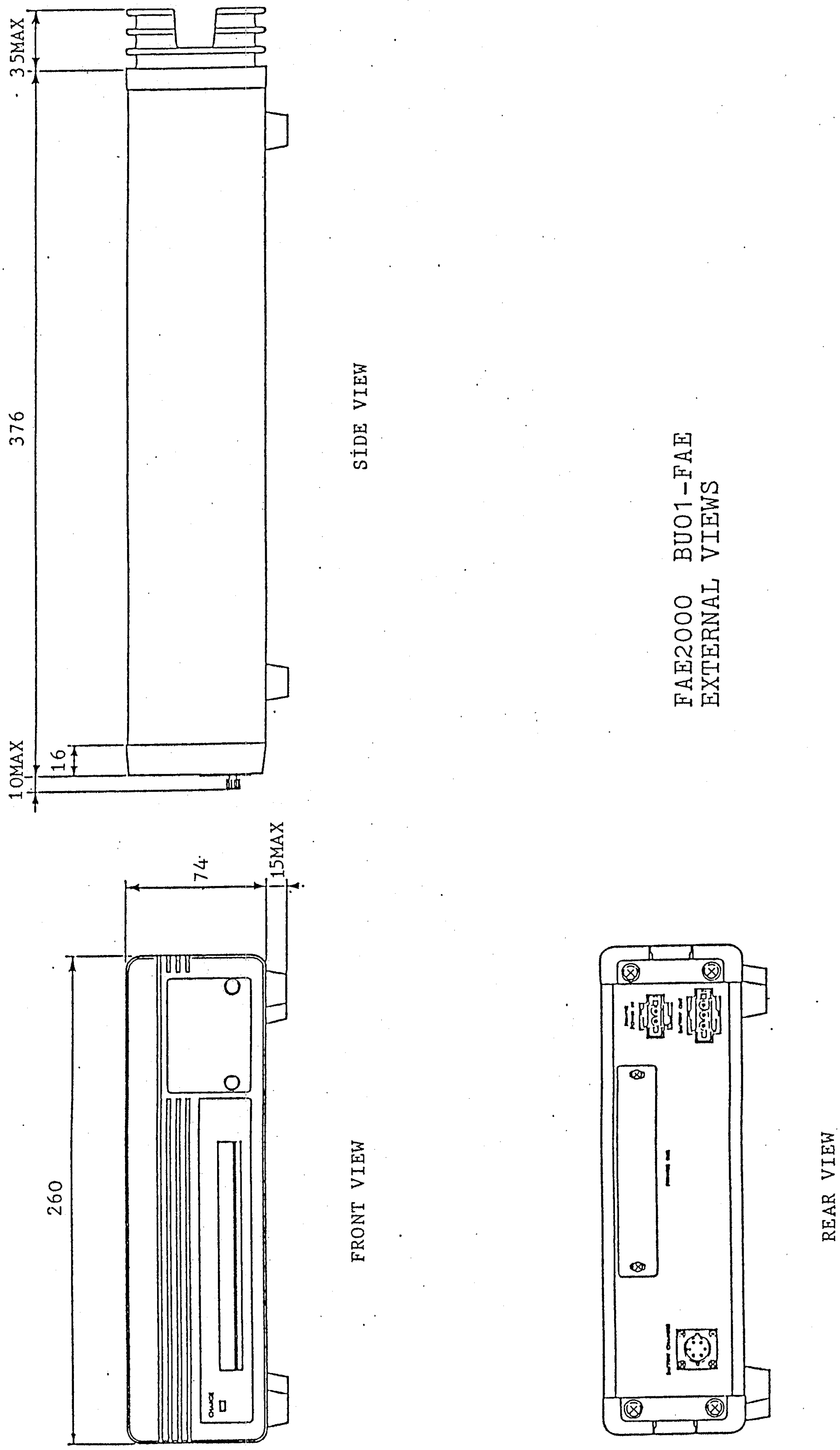
CHAPTER 16. EXTERNAL VIEWS




35MAX
376
16
10MAX
SIDE VIEW
FAE2000 BU01-FAE
EXTERNAL VIEWS
74
15MAX
260
FRONT VIEW
REAR VIEW

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CHAPTER 17. BASICS OF FFT ANALYZER

As a very powerful general-purpose signal analyzer, the FFT Analyzer requires operators to know its basics for effective use and accurate understanding of the results obtained. What follows is a simple presentation of some basic facts about the FFT Analyzer. This chapter covers the following:

17.1 Configuration of the FFT Analyzer

Figure 17.1 shows a typical configuration of the FFT Analyzer.

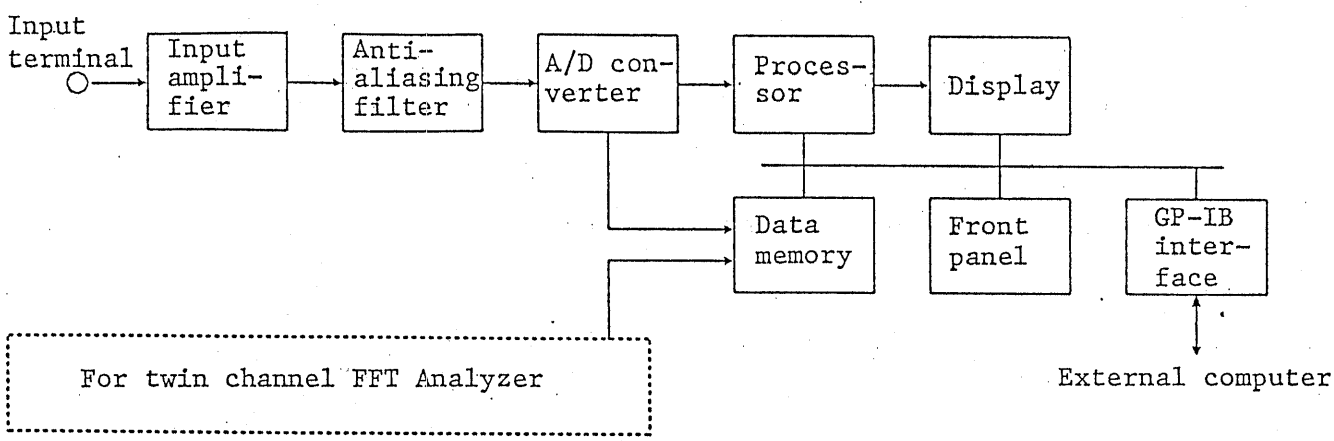


Fig. 17.1 Typical Configuration of the FFT Analyzer

Input signals are amplified or reduced to an acceptable level by the amplifier before entering the anti-aliasing filter. The anti-aliasing filter eliminates all signal elements exceeding the target frequency range for frequency analysis so that the results will be accurate.
The signals then enter the A/D converter for conversion to digital quantities which in turn are stored in data memory. The stored signals are output to the display, after either being processed by the processor or forwarded to an external computer via the GP-IB interface, depending on the instruction from the front panel. For the twin-channel FFT Analyzer, another analog portion of the input amplifier through the A/D converter (enclosed by broken lines) is added to implement one more channel.

17.2 FFT

The acronym FFT, which stands for Fast Fourier Transformation, means what it says: calculating Fourier transformation at high speed. Although they are a powerful aid to theoretical study in science and technology, Fourier transformation used to require lots of time-consuming calculations when performed. Today, advances in semiconductor technology have made the means for high-speed calculation economically available. At the same time, techniques have been devised (FFT) whereby the amount of calculation for Fourier transformation can be greatly reduced. These two developments have made it possible to implement readily available FFT Analyzers, of which our Analyzers are among the types of highest performance.

As shown in Fig. 17.2, Fourier transformation theoretically gives us nothing unless a given signal is observed from the infinite past to the infinite future. Since this is obviously impossible, the ordinary practice is to observe the signal for a finite period of time. Fourier transformations are approximated by finding a Fourier series on the basics of this observation period used as the fundamental period (see Fig. 17.3).

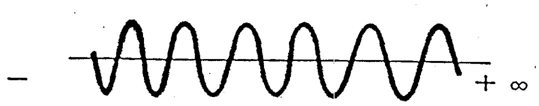


Fig. 17.2

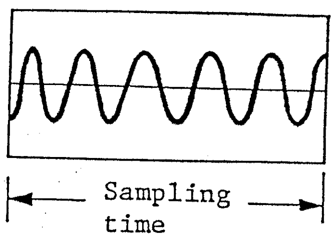


Fig. 17.3

To calculate this Fourier series requires integrating the product of the observed signal and a complex exponential function with respect to time. Because this kind of calculation cannot be performed directly by computer, the observation period is split into an appropriate number of divisions.

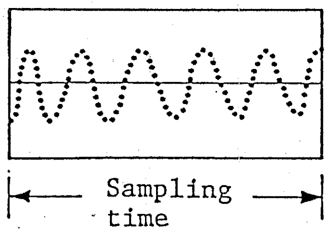


Fig. 17.4

Then only the signal value at each of the dividing points is used to approximate the product (see Fig. 17.4).

In computerizing physical quantities, an A/D converter is used to convert the object of observation from analog to digital format. That is, temporally continuous analog quantities are converted to temporally discontinuous (discrete) digital quantities for computation. This process necessarily involves introducing approximations. Such approximations give rise to the need to consider the magnitude of error between a true Fourier series obtained by an analytical technique that integrates the actual analog signal, and the Fourier series obtained by the above-mentioned approximation. But sampling theory (discussed later) makes it clear that with certain conditions satisfied. Approximation based on temporarily discontinuous digital quantities matches the true Fourier series. The FFT analyzer is designed to meet these conditions.

The process of observing for a finite period of time, then obtaining a Fourier series by splitting that period into divisions, is called Discrete Fourier Transformation (DFT). The high-speed technique for calculating of DFT is Fast Fourier Transformation, or FFT. To use the FFT Analyzer requires understanding clearly how the results of the analysis are related to the duration of the observation period, the number of divisions of that period, and other factors. The high-speed calculation techniques of FFT are not directly associated with the results of analysis.
Generally, the finite observation period is called a frame, and the duration of that period the frame time. The procedure of splitting the observation period into divisions and obtaining a

signal value at each dividing point is called sampling. The temporal interval for these divisions is called a sampling cycle (the reciprocal of the sampling cycle is the sampling frequency). With the FFT Analyzer, one frame generally consists of a fixed number of sampling points: 512, 1024, 2048, etc.

It can be seen from the above that the frequency resolution of the FFT Analyzer is the reciprocal of the frame time, and that the spectrum frequency obtained is an integral multiple (0, 1, 2, ...) of the frequency resolution.
This means that the frame time needs to be long (i.e., that it is necessary to conduct observation for a long time) in order to obtain a high frequency resolution.

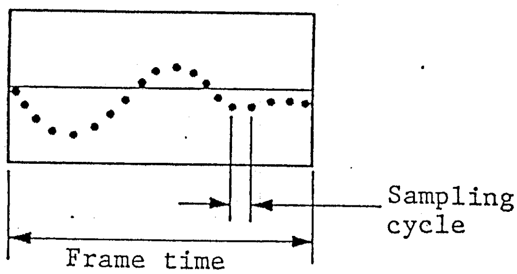


Fig. 17.5

17.3 Sampling

In 17.2, Fast Fourier Transformation (FFT) was discussed with a view to making approximation calculations easy to understand. A deeper understanding in this respect is available with the aid of general sampling theory, which will be outlined below. According to this theory, the following typically occurs: A temporally continuous analog signal with a spectrum as shown in Fig. 17.6 is sampled at sampling frequency fs.
This product a temporally discrete signal whose spectrums are those reproduced in the same shape flanking the original at integrally multiplied locations of sampling frequency fs ($-\infty$, ..., -2 fs, -fs, 0, fs, 2 fs, ...), as shown in Fig. 17.7.

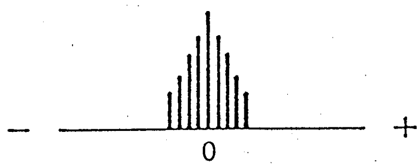


Fig. 17.6

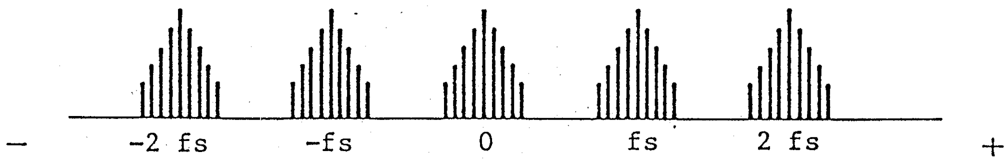


Fig. 17.7

If the spectrum in Fig. 17.6 contains higher frequency elements, as shown in Fig. 17.8, the sampling produces spectrums with overlaps as shown in Fig. 17.9. This phenomenon is called aliasing.

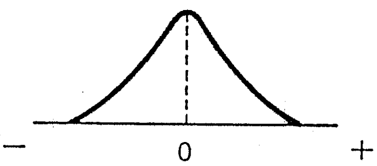


Fig. 17.8

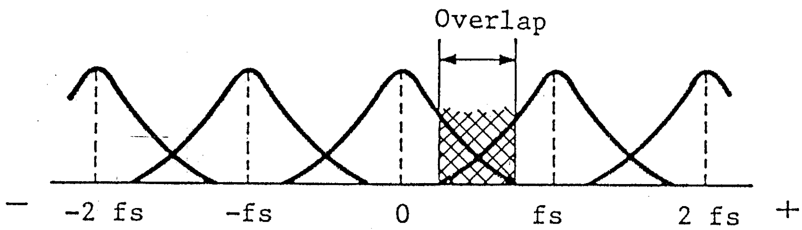


Fig. 17.9

If the original analog signal contains still higher frequency elements, the spectrums resulting from the sampling develop overlaps throughout the entire frequency range. In such cases, there is no room in which to preserve the original spectrum (see Fig. 17.10).

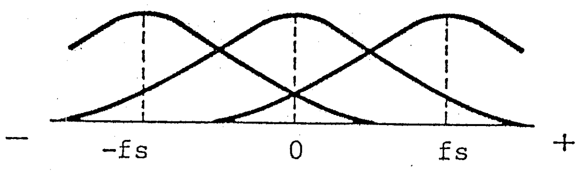


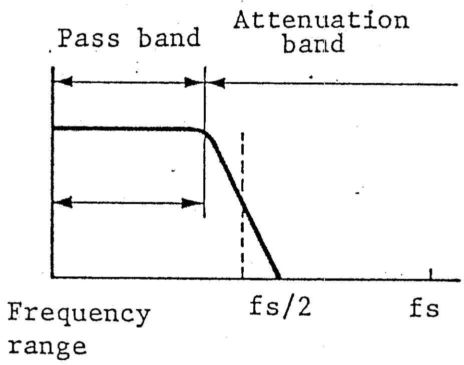
Fig. 17.10

These overlaps make it impossible to keep the spectrum in the original shape. Given this disturbance, accurate spectrum analysis cannot possibly be achieved.

To eliminate the overlaps requires making the original analog signal free of all frequency elements higher than half the sampling frequency. This may be accomplished in two ways. One way is to subject the analog signal to a low-pass filter to remove higher frequency elements. The other is to perform sampling at a sampling frequency at least twice as high as the highest frequency elements contained in the analog signal. In most devices, including the FFT Analyzer, a low-pass filter is incorporated in the signal input section. The burden on the downstream signal processing section is reduced by having the filter keep the sampling frequency as low as possible. This low-pass filter is called an anti-aliasing filter.

When a single frame contains N sampling, points, the sampling frequency = N/(frame time), i.e., N times the frequency resolution.

As a result of frequency analysis by the analyzer, the frequency range for reliable spectrum display without aliasing is theoretically up to half the sampling frequency from DC.



In fact, because the high attenuation curve of the anti-aliasing filter changes gradually as shown in Fig. 17.11, there is some portion of the frequency area where aliasing occurs.

Fig. 17.11

That is, the reliable frequency range extends from DC to frequencies lower than half the sampling frequency. This frequency range is determined by the relationship between the difficulty in designing the anti-aliasing filter and the sampling frequency adopted.
Generally FFT Analyzers operate on the following relationship:
Sampling frequency = frequency range times 2.56 or 4.096

When a single frame contains N sampling points, subjecting these points to FFT produces N spectrums in the frequency range (from DC to sampling frequency). It follows that the number of spectrums in the frequency range, with the DC element included, is $1+N/2.56$ or $1+N/4.096$.
This value usually gives 201, 401, 501, etc. as the number of spectrum. Obviously, frequency resolution = frequency range/(spectrum count (200, 400, 500, etc.)).

17.4 Windows

It was mentioned earlier that the FFT Analyzer finds the Fourier series of any input signal by regarding it as a periodic signal whose cycle is the frame time. This frame time is determined by analyzer design, and remains unchanged regardless of the input signal. To illustrate, putting an input signal having the sine wave shown in Fig. 17.12 into the frame actually means trying the Fourier series of the repeat signal depicted in Fig. 17.13.

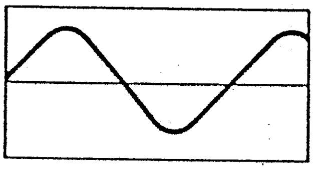


Fig. 17.12

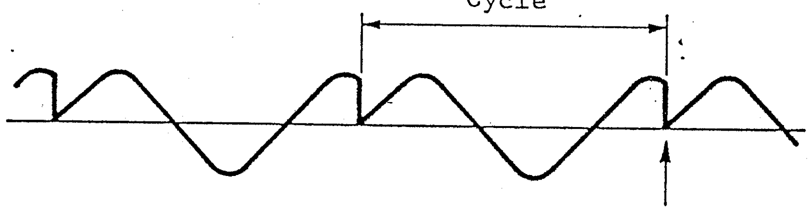


Fig. 17.13

In the process, discontinuous points occur at the beginning and end of the frame. This causes spectrums containing numerous harmonics to be obtained in addition to the spectrum with the original sine wave. This phenomenon is called leakage. There are some exceptional cases where discontinuous points do not occur. For example, the cycle of a sine wave may fall snugly within the frame as shown in Fig. 17.14 (When the frame time is equal to a cycle that is an integral multiple of the input signal). Or a transient phenomenon may occur in which the beginning and end of a signal converge on the same value, as depicted in Fig. 17.15. In such cases, the original spectrum can be accurately obtained.

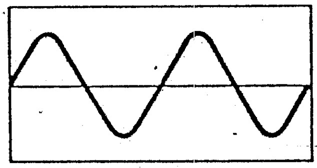


Fig. 17.14

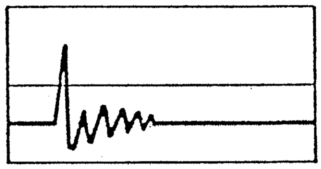


Fig. 17.15

However, these favorable conditions cannot be expected in analyzing cyclic signals. The leakage needs to be minimized. One way to do this is to multiply the original input signal with a function called a "window" to deform the waveform for convergence on zero at the beginning and end of the frame, thereby eliminating the occurrence of discontinuous points. The input signal in Fig. 17.16, when processed with a window, turns into the signal shown in Fig. 17.17. The Analyzer finds the spectrum based on the window-processed signal in Fig. 17.17.

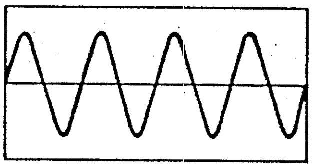


Fig. 17.16

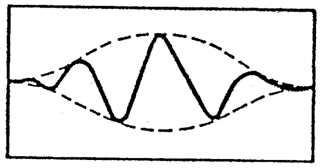


Fig. 17.17

For display purposes, the original signal is presented with no window processing performed on it.
Such window functions are required to reproduce the original spectrum as faithfully as possible with a minimum of leakage. The most commonly used windows have rectangular, hanning and flattop shapes. The rectangular window actually means the window where no processing is done. But it is usually regarded as a distinct window in which the original input signal in the frame is kept intact.

Figures 17.18 through 17.20 outline the shapes of these windows for reference.

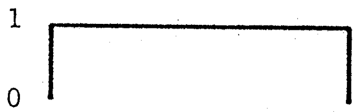


Fig. 17.18
Rectangular

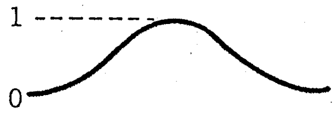


Fig. 17.19
Hanning

Fig. 17.20
Flattop

As can be seen from Fig. 17.19 and 17.20, window processing reduces the signal to zero at the beginning and end of the frame. That is, an input signal having important data in these portions will lose it if subjected to spectrum analysis.
The input signal shown in Fig. 17.21 contains important data at the beginning of the frame. After window processing, most of the data is lost, as depicted in Fig. 17.22. In this case, it is necessary to admit the input signal in such a way that signal part to be analyzed is positioned in the middle of the frame (window is the hanning or flattop type).

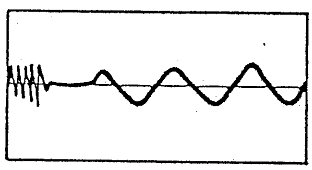


Fig. 17.21

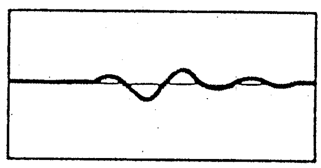


Fig. 17.22

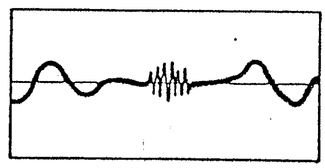


Fig. 17.23

Where a window is used in which the signal from a transient phenomenon would be partially lost at either end of the frame, the key signal portion should be located in the middle of the frame.

As mentioned earlier, the frequency value of spectrums that can be obtained by the FFT Analyzer is limited to those values that are integral multiples of the frequency resolution. The FFT

Analyzer observes the spectrum peak value of a cyclic signal at a given frequency of that peak value. If the result reveals a discrepancy between the input signal frequency and an integral multiple of the frequency resolution, a peak value a little lower than the actual spectrum peak value is obtained. Depending on the window type used, an error of about half the frequency resolution theoretically occurs between the actual frequency and the frequency indicated by the observed value. Figure 17.24 shows an example where no such error takes place, and Fig. 17.25 an example where it does.

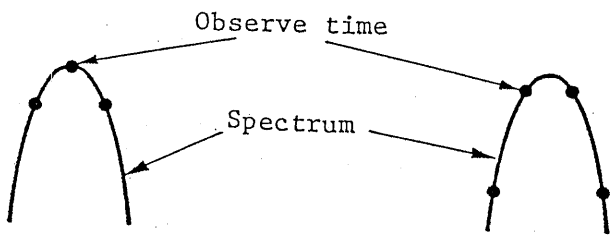


Fig. 17.24 Fig. 17.25

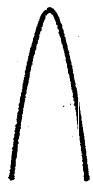
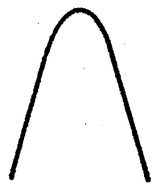
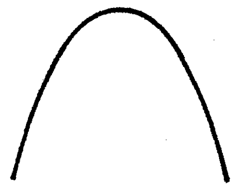
This error is intrinsic to the processing. The magnitude of the error is determined by the input signal frequency, the frequency range for analysis, and the window type. Table 1 lists general characteristics of the windows.

Table 1

Window	Frequency resolution	Peak value error	Major application
Rectangular	◎	x	For transient phenomena and special input signals that generate no leakage
Hanning	o	o	For common cyclic signals
Flattop	x	◎	For accurately obtaining peak values of fixed-cycle signals

Table 2 compares the spectrum peak shapes among the windows.

Table 2

Rectangular	Hanning	Flattop
		

17.5 Real-time Analysis and Overlapping

One of the operations by which the FFT Analyzer admits an input signal for analysis is called a free-run. In a free-run operation, the Analyzer repeats the analysis at the highest design speed with no synchronization with the input signal. At this time, there can be three types of processing (Fig. 17.26 through 17.28) depending on the relationship between the frame time and the Analyzer's processing time (for calculations, display, etc.).

Figure 17.26 shows a case where the processing time is longer than the frame time, allowing one or more frames of the input signal to be admitted upon completion of process 1. As can be seen from the figure, part of the input signal is lost.

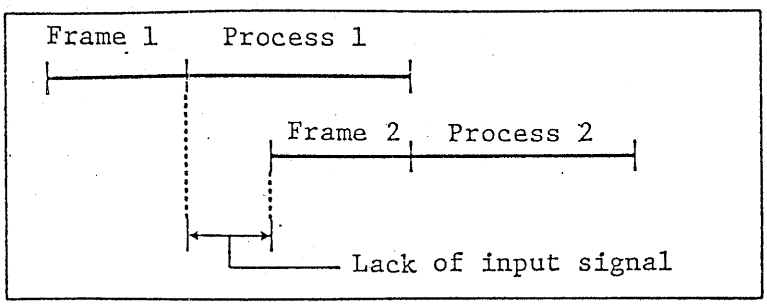


Fig. 17.26

Figure 17.27 shows a case where the frame time equals the processing time, with the entire input signal processed.

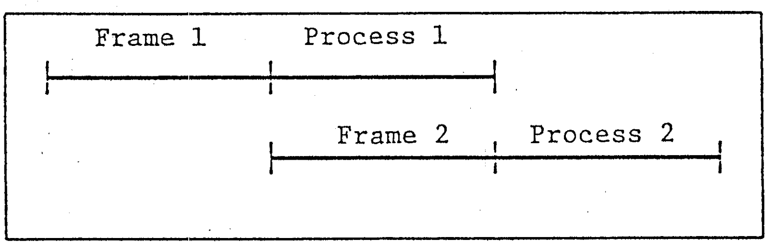


Fig. 17.27

Figure 17.28 shows a case where the frame time is longer than the processing time. Here, part of frame 1 of the input signal used in process 1 overlaps frame 2 of the input signal for use in process 2.

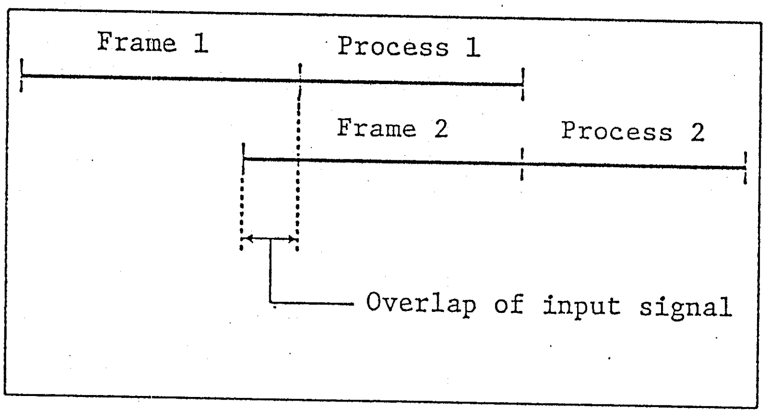


Fig. 17.28

The frequency in the range corresponding to the frame time where no part the input signal is lost (Fig. 17.27) is called a real-time frequency. This frequency is a guide indicating the capacity of the FFT Analyzer, i.e., its analyzing speed.
The higher the real-time frequency, the higher the processing (analyzing) speed. Input signals are not overlapped in any operation (Auto Armed or Armed) other than free-run.
Carrying out averaging in a free-run operation causes the overlapping shown in Fig. 17.28. As the rate of over-lapping increases, the signal in each frame begins to develop strong correlation. It should be noted that with the specified averaging count exhausted, the results obtained may be those corresponding to a lower averaging count. However, higher overlapping rates may be preferred for peak hold and exponential averaging operation.

17.6 Histograms

Although it has no direct relation to FFT, the histogram is one of the items analyzed by the FFT Analyzer. As shown in Fig. 17.29, the histogram involves splitting a signal into small divisions in the horizontal direction. Then the probability of each division having the signal is obtained by dividing the sum of times for the signal to exist in these divisions by the frame time. (The probability may be replaced by a function of probability density, or some other quantity proportionate to the probability.)

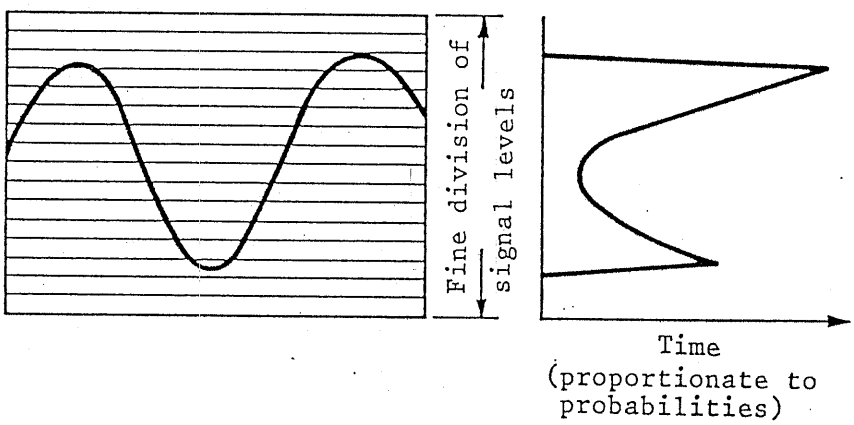


Fig. 17.29

When admitting a signal existing uniformly in all the divisions, the FFT analyzer splits the signal so that each division will contain four sampling data items. That is, where the number of sampling points per frame is 512, 1024, 2048, etc. the signal is split respectively into 128, 256, or 512 equal divisions. The number of sampling data items in each division is then observed and formed into a histogram.

17.7 THP and THD

THP (Total Harmonic Power) and THD (Total Harmonic Distortion) are processed measurements associated with quantities of power in dominant and harmonic waves. These values are useful for analyzing elements of vibrations, etc.
THP is the total amount of harmonic power, and THD is the percentage of THP with respect to the dominant wave.

$$THP = \sqrt{Vr_2^2 + Vr_3^2 + \ldots\ldots + Vr_n^2} \quad (Vrms)$$

(n is a positive integer)

$$THD = \frac{THP}{Vr_1} \times 100 \ (\%)$$

Vr_1 : effective value of dominant wave

Vr_n : effective value of each harmonic wave