INSTRUCTION MANUAL

SIGNAL ANALYZER

SA-77

RION CO., LTD.

PRECAUTIONS

● Operate the unit as described in this manual.

● Do not disassemble the unit or attempt internal alterations.

● In case of malfunction, do not attempt any repairs. Note the condition of the unit clearly and contact the supplier.

● Observe the following precautions before using the unit:
   1) Check the setting of all switches and controls, and make sure that the unit is operating normally.
   2) Make sure that all connections are properly established.

● The permissible ambient temperature range for operation of the unit is 5 to 40°C (specifications guaranteed), and 0 to 50°C (operation guaranteed). Relative humidity must be below 90%.

● Do not use or store the unit in locations which
   1) may be subject to strong magnetic fields or radiation, or
   2) may be subject to splashes of water or to direct sunlight, or
   3) may be subject to high temperature, humidity, dust, or air with high salt or sulphur content, or
   4) may be subject to gases or are in the vicinity of stored chemicals, or
   5) do not provide a firm, level support without danger of vibrations or shock.

● Do not forget to turn the unit off after use.

● When disconnecting cables, always hold the plug and do not pull the cable.

CONTENTS

OUTLINE

The SA-77 is a highly compact, lightweight FFT signal analyzer. It accepts direct input from accelerometers with built-in preamplifier or microphones with integrated preamplifier, permitting vibration or noise measurements and immediate analysis in the field. The supplied external input adapter allows input of electrical signals via a BNC connector.

The SA-77 offers a host of useful features, such as display of time waveform, spectrum, or PDF (amplitude probability density function), as well as phase display for example to check for unbalances in rotating machinery, and envelope display to test bearing conditions.

Waveform data can be stored in the memory of the unit and FFT analysis can be performed on any part of recalled data. Memory contents are preserved by a lithium backup battery also when the unit is turned off.

The optional printer CP-10 makes it easy to obtain hard copy of displayed data, and the built-in RS-232-C interface allows setting of measurement parameters under external control and transfer of measurement data to a computer. For details on operation of the RS-232-C interface, please refer to the separate manual.

PANEL EXPLANATION

● Front Panel

Signal input connector

Display

Operation keys

Cursor keys ($\triangle$, $\triangledown$, $\triangleleft$, $\triangleright$)

Power On/Off key (PWR)
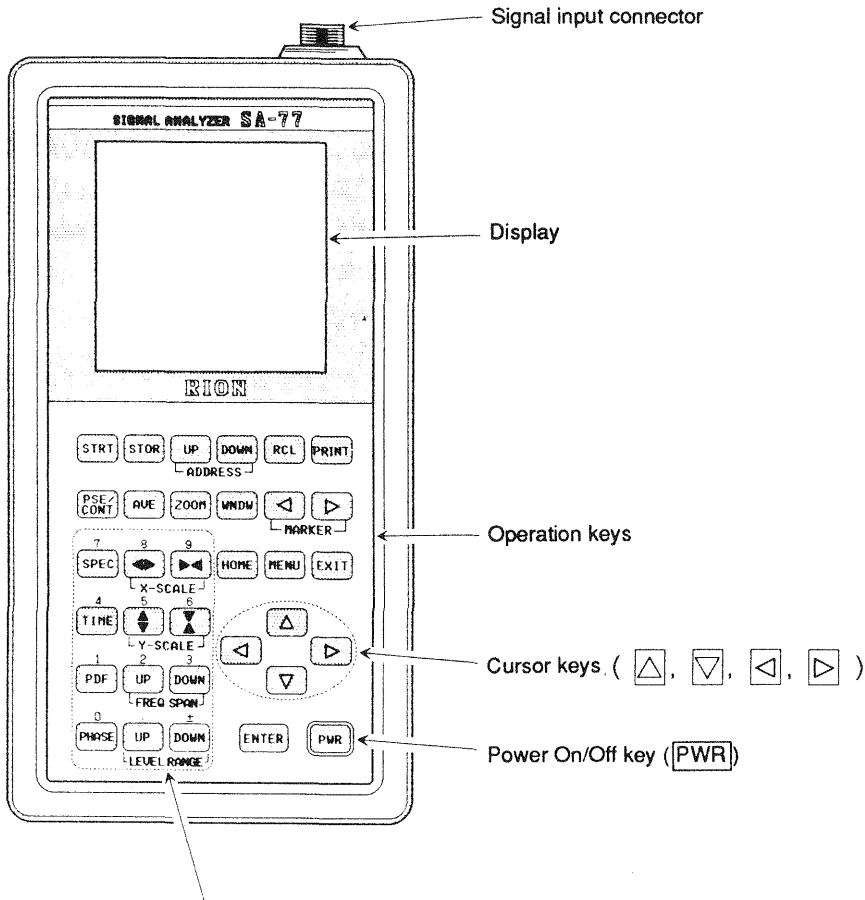
These keys also serve as numeric keypad for entry of analysis parameters.
The function of each key is indicated by the lettering above it (0 , 1 , 2 , ... 9 , . , ±)

In this manual, operation keys are shown with the lettering that appears on the key face. In case of multiple keys with similar functions such as UP or DOWN , the lettering below the key is also shown in brackets, such as UP [ADDRESS] etc.

● Side Panel

I/O connector

AC adapter input jack

External trigger signal input jack

Reset button

AC output jack

External sampling signal input jack

Contrast control

Signal input connector
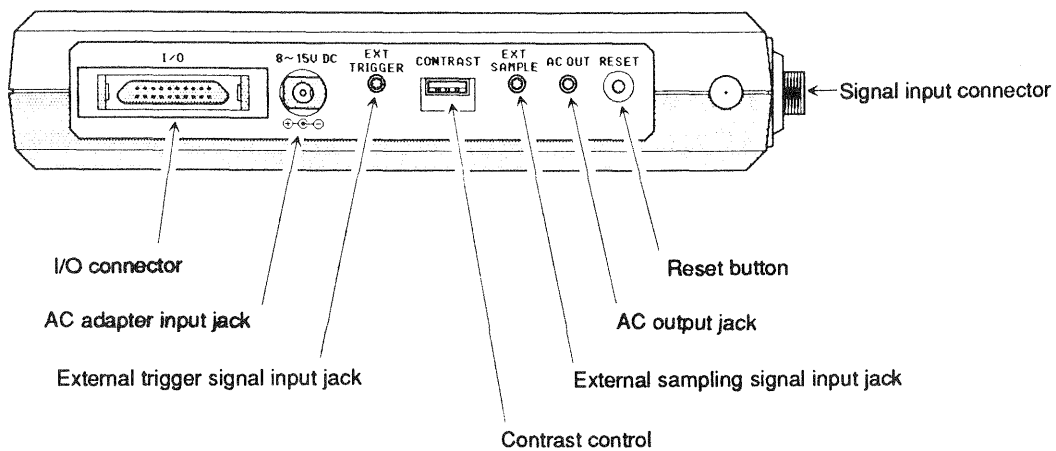
INSERTING THE BATTERIES

This unit is powered by eight internal IEC R6 (size AA) batteries or by the optional AC adapter (NC-10 or NC-11). Memory data are retained by a lithium backup battery (CR-1/3N).
For connection of the AC adapter, refer to page 6.

1. Remove the battery compartment cover by pressing the lever in the direction of the arrow and lifting the cover.

Cover Lever   Ribbon   Lithium battery
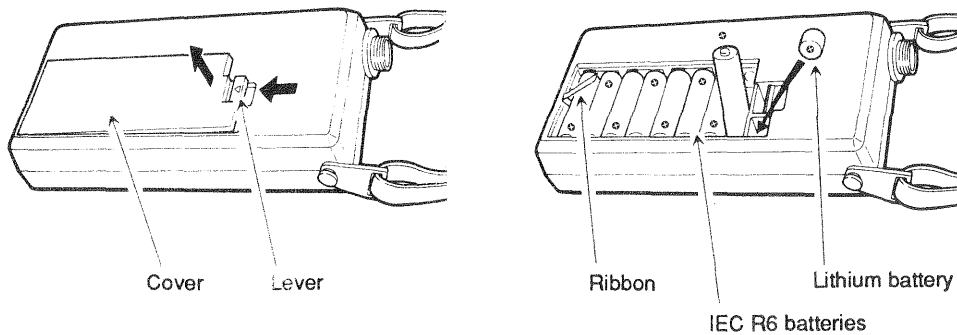
IEC R6 batteries

2. Insert the eight IEC R6 batteries, taking care to observe correct polarity. The batteries should be placed over the ribbon.

3. Insert the lithium battery, taking care to observe correct polarity.

4. Note the replacement date for the lithium battery on the label on the reverse side of the battery compartment cover, and replace the cover.

⊖   ⊕

CR-1/3N
(SANYO)
DATE OF BATT.
REPLACEMENT

1	Oct. 10, 89
2	
3	
4	
5	
6	
7	
8	

REPLACE BATT.
EVERY YEAR.

Note date of lithium
battery replacement.

● Battery Life

• IEC R6 batteries
When the unit is operated on batteries, combined battery voltage will decline gradually. The indication "LOW" appears when the voltage falls to about 9 V, and the indication "EMPTY" appears when the voltage falls to about 8 V. If the unit is further used beyond this point, it will shut itself off automatically after about 10 minutes. To avoid interruptions during use, replace all batteries with fresh ones as early as possible (preferably immediately when the "LOW" indication comes on), or power the unit from the AC adapter.

Battery life depends on various factors such as battery type and ambient temperature. The chart below shows a representative example for continuous use of the unit at 20 °C with manganese and alkaline batteries.
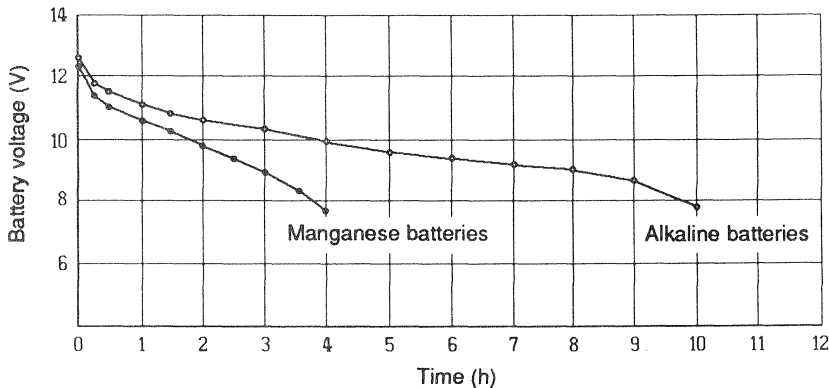
• Lithium battery
The internal lithium battery serves as backup for the data stored in RAM. The life of this battery is about 2 years, but there is no provision to check the condition of this battery. Therefore a label is provided on the inside of the battery compartment cover to keep track of battery replacement dates. To be on the safe side, change the lithium battery once a year.

Note: When the lithium battery is replaced, all data stored in the unit are lost. Before changing the battery, transfer any data you want to keep to a computer via the RS-232-C interface.

CONNECTIONS

External input adapter UA-01

BNC connector

Signal analyzer SA-77

I/O   8~15V DC   EXT TRIGGER   CONTRAST   EXT SAMPLE   AC OUT   RESET

Connecting cable
(CC-81)

External output cable
(CC-24)

Printer * CP-10

Data recorder or
level recorder

Connecting cable
(CC-80)

Computer

External sampling signal
(TTL level)

To RS-232-C
interface connector

AC adapter
NC-10 or NC-11

External trigger signal
(TTL level)

↓ To AC power line

* Set the dipswitches of the printer as shown below.

DIP01   DIP02

ON   ON

1 2 3 4 5 6 7 8   1 2 3 4 5 6

ON OFF   Any setting   OFF

Signal from sound level meter, vibration meter or other equipment (with BNC output connector)

Preamplifier NH-17

Electret condenser microphone
UC-52 (for general applications)
UC-53 (for high-precision applications)

Accelerometer (with preamplifier)
PV-57 (magnetic type)
PV-55 (application type)

Preamplifier VP-26C

Accelerometer
PV-90B (compact type)
PV-85 (universal type)
PV-87 (high-sensitivity type)
PV-65 (high-temperature type)

Vibration input adapter UA-07

Accelerometer PV-11
(water-proof, isolated, stationary type)

POWER-UP AND MODE SELECTION

● Turning the unit on

When the PWR key is pressed, power to the unit is turned on and one of the analysis mode screens shown on page 9 is displayed. (The setting selected before the unit was turned off is memorized, and the same setting will be active when the unit is next turned on.)

Adjust the CONTRAST control on the side of the unit for best readability of the display.

CONTRAST control
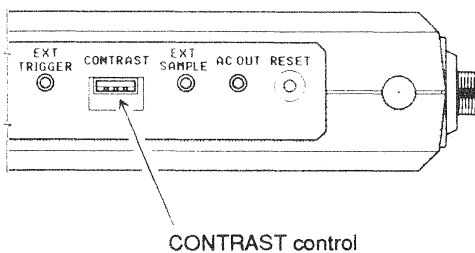
● Mode selection

The SA-77 has three operation modes: analysis mode, analysis parameter setting mode, and recall mode. To switch between modes, use the MENU , RCL , and EXIT keys. (Refer to the illustration on page 9.)

· Analysis mode
In this mode, the input signal is analyzed and its spectrum, time waveform, PDF, or phase is displayed. To switch between the display functions, use the SPEC (spectrum), TIME (time waveform), PDF and PHASE keys.

· Analysis parameter setting mode
This mode includes four menus which serve to set various parameters. To switch between the menus, use the MENU and HOME keys.

· Recall mode
This mode serves to recall stored data from memory, and perform analysis on such data. (If there are no stored data, the indication "NO DATA" appears on the display.)

PWR ─ Unit is turned on.

☐ ──▶ : Press key shown in frame.

Analysis mode

SPEC

TIME

Spectrum display

Time waveform display

MENU

MENU

EXIT

Analysis parameter setting mode

Menu 1

0001   MENU (1)

FREQ SPAN:
LEVEL RANGE: 20dBVr
0dBEU=   0.0dBVr OFF

HPF:OFF   LPF: OFF
COUPLING: AC
ENVELOPE: OFF

ZOOM: #1
WINDOW: RECT

EXT

Menu 2

0001   MENU (2)

AVERAGE DOMAIN:
    MODE: INST
    N : ####

TRIGGER SOURCE: INT
    MODE: FREE
    LEVEL: +0/8
    SLOPE: +
    N : + - 0

TIME PDF

MENU

HOME

MENU HOME

HOME MENU

Menu 4

0001   MENU (4)

PANEL
    STORE :
    RECALL: 1

MASS MEMORY
    STORE_TYPE: MANU
    CLEAR : 1.. 1
    STEP: ▲ 1

CMNT: OFF

Menu 3

0001   MENU (3)

SPEC OPE:
Y-AXIS : log
X-AXIS : Hz

DISPLAY Y-GRID: ON
HARMONIC LINE: OFF
MARKER LINE: ON

BAUD RATE : 4800
POWER SAVE: OFF

-1/ω² 1/ω 1ω -ω²

HOME

MENU

PDF

PHASE

PDF display

Phase display

RCL   EXIT

MENU   EXIT

Recall mode

SPEC

TIME

PDF

PHASE

Spectrum display

Time waveform display

PDF display

Phase display

● Making a hard copy of the screen display
When the optional printer CP-10 is connected, pressing the PRINT key produces a hard copy of the currently shown display.

```
 0001                SPEC
                     RCL
                     MANU
                     log
                     y   1
                     x   1
                     *1
                     RECT
                     FREE
                     INST
                     5K
                     20
 1350.0 Hz  -  22.1  dBVr
```
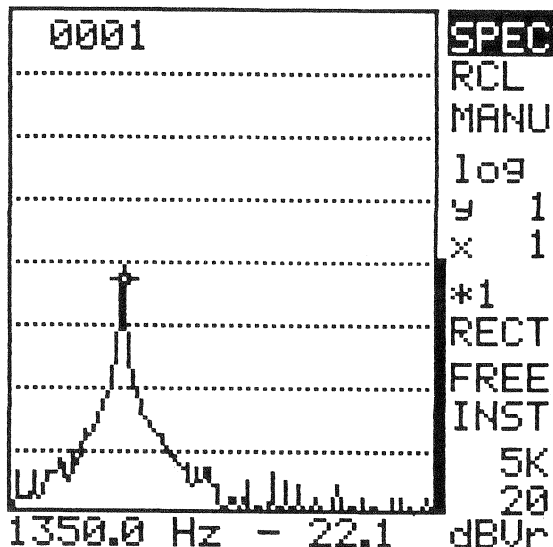
Hard copy example (actual size)

● Reset
If a function error has occurred or the unit has locked up (keys do not work), press the RESET button on the side of the unit with a pointed object such as a pencil. Data stored in memory will not be erased by the reset operation.
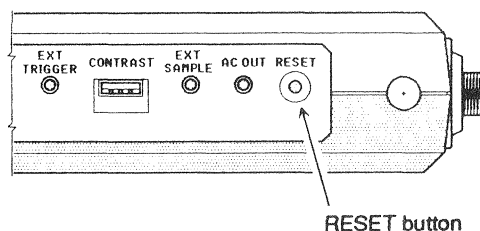
RESET button

If the unit still dose not work properly even after pressing the RESET button, disconnect the AC adapter and remove the IEC R6 batteries and the lithium battery. Then reinsert the batteries and turn the unit on again. In this case, all data stored in memory will be lost.

● Turning the unit off
Press the PWR key once more to turn the unit off.
If the AC adapter is unplugged or the batteries are removed before turning the unit off, the setting that was active before may not be restored the next time the unit is turned on.
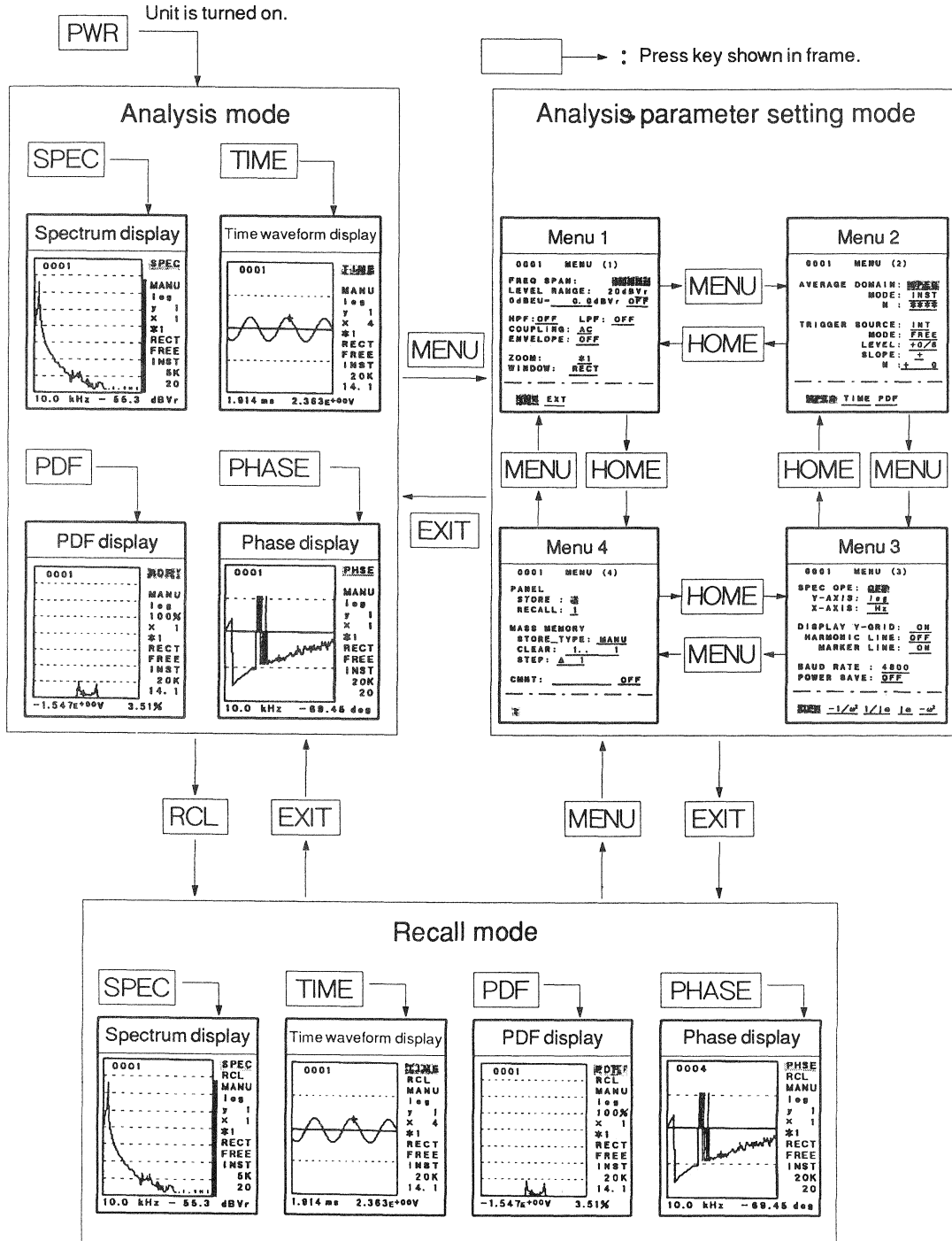
ANALYSIS MODE

In this mode, the input signal is analyzed and its spectrum, time waveform, PDF, or phase are displayed. To switch between the display functions, use the SPEC , TIME , PDF , and PHASE keys. The currently selected display setting is shown in reverse at the top right of the display.
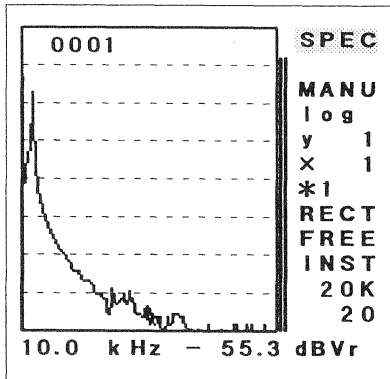
Spectrum
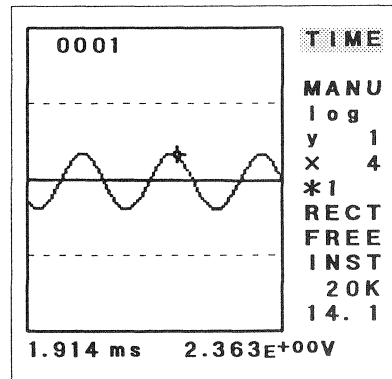
Time wafeform
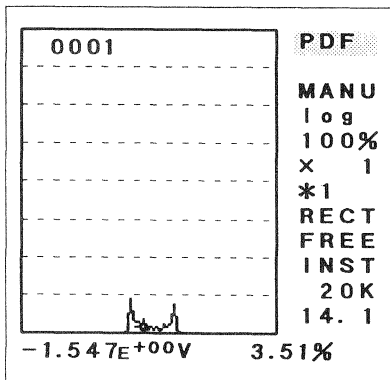
PDF
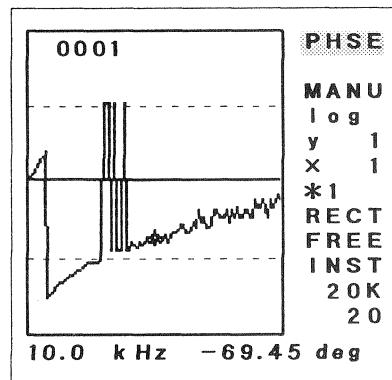
Phase

■ Reading the Display

In the analysis mode, the display shows data and parameter settings as shown in the example below. The type of data display depends on the chosen parameters. In the example, the spectrum setting is chosen. The part of the display showing the parameters is basically the same for all data types.
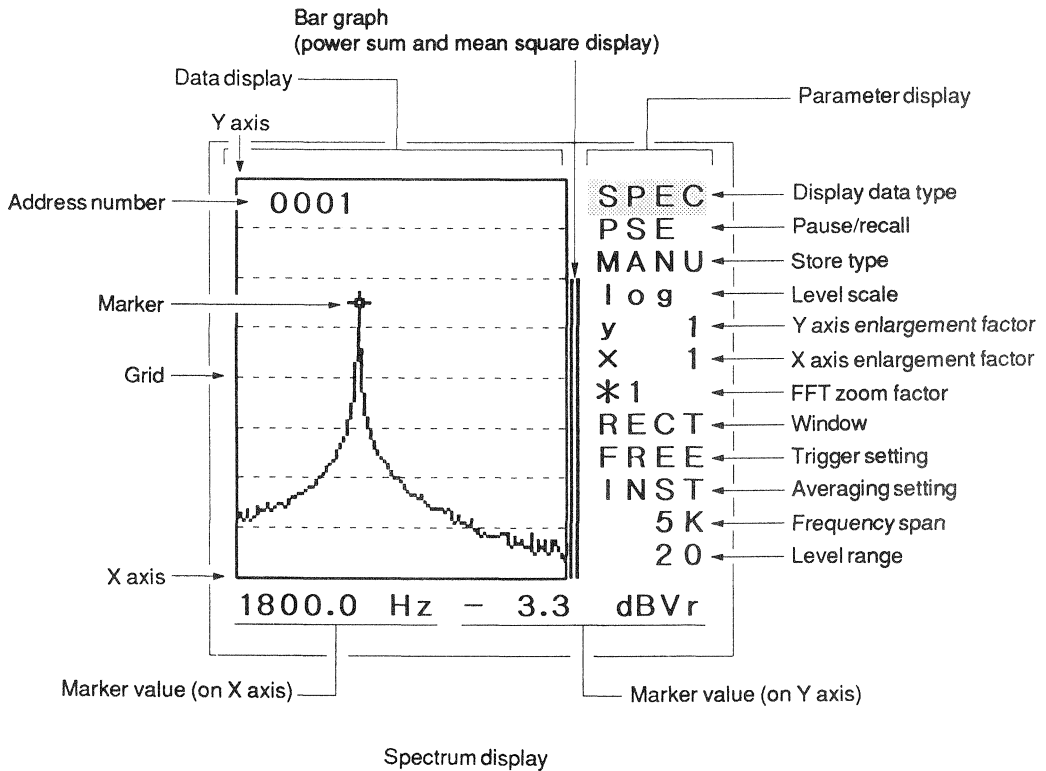
Spectrum display

Depending on the selected data type, the X axis and Y axis have the following definitions.

Display data type	X axis	Y axis
Spectrum	Frequency	Level (voltage)
Time waveform	Time	Level (voltage)
PDF	Level (voltage)	Amplitude probability density
Phase	Frequency	Phase

Marker: The marker can be moved with the ◁ · ▷ [MARKER] keys to any point on the data display, to read the value at that point.

Marker value: X axis and Y axis value at the marker point.

Bar graph:

In the spectrum display mode, power sum of spectrum level data and mean square value of time waveform data are displayed to the right of the spectrum display area. During time waveform, PDF, and phase display, the bar graph is off.

● Reading the power sum and mean square values

In the spectrum display mode, each push of the SPEC key changes the X-axis marker definition as follows.

Hz (KCPM/ORD) → <P.SUM>f → <RMS>t → Hz (KCPM/ORD) ∙∙∙

When <P.SUM>f or <RMS>t is chosen, the power sum or mean square value is displayed in place of the spectrum frequency and level.

<P.SUM>f :

Power sum of spectrum level data for each frequency (without DC component)
$$<P.SUM>f = \sum |F(i)|^2$$
where F(i): fourier transform value

<RMS>t :

Mean square value of time waveform data corresponding to displayed spectrum (without DC component)
$$<RMS>t = \sum f(i)^2/N$$
where f(i): time waveform data, N: number of samples per frame
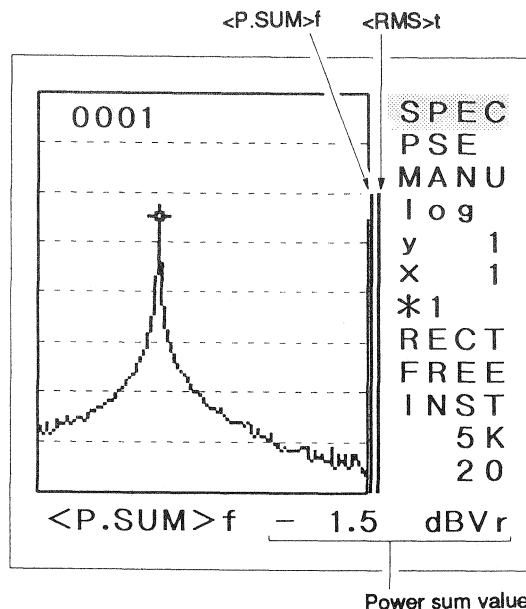
Power sum display

■ Parameters

● Display data type
Shows which kind of data display is selected.

| SPEC | : | Spectrum | PDF | : | Amplitude probability density function |
| TIME | : | Time waveform | PHSE | : | Phase |

● Pause/recall
Reads "PSE" in the pause condition and "RCL" in the recall mode.

● Store type
Indicates which way of storing data in memory is selected. This setting is performed from menu 4 (☞ p. 54).

> MANU: Manual store
> AUTO: Auto store
> TRSN: Transient store

● Level scale
Shows which scale (logarithmic or linear) is selected for the Y axis of the spectrum display. This setting is performed from menu 3 (☞ p. 49).
For the time waveform and PDF, the level scale is always linear, regardless of the setting of this parameter.

> log: Logarithmic scale
> lin: Linear scale

● Y axis enlargement factor
Indicates the enlargement factor on the Y axis.
When the spectrum, time waveform, or PDF display is selected, pressing the ⬦ [Y-SCALE] or ⬦ [Y-SCALE] key increases or decreases the enlargement factor. For phase display, the factor is always 1 and cannot be changed.
The range within which the enlargement factor can be set depends on the display setting, as shown in the table below.

Display data type	Enlargement factor range						
Spectrum	1 , 2 , 4 (logarithmic scale)						
	1 , 2 , 4 , 8 , 16 , 32 , 64 , 128 (linear scale)						
Time waveform	1 , 2 , 4 , 8 , 16 , 32 , 64 , 128						
PDF	Screen display	100%	50%	25%	10%	5%	2.5%	1%
	Enlargement factor	1	2	4	10	20	40	100

For spectrum and time waveform display, the actual enlargement factor is shown. For PDF display, the percentage of display data along the Y axis is shown.
When enlargement is performed, not all data can be viewed at once. Move the display area to view the desired section (☞ p. 31).

● X axis enlargement factor
Indicates the enlargement factor on the X axis.
When the spectrum, time waveform, or phase display is selected, pressing the ⟦◄►⟧ [X-SCALE] or ⟦►◄⟧ [X-SCALE] key increases or decreases the enlargement factor. For PDF display, the factor is always 1 and cannot be changed.
The range within which the enlargement factor can be set depends on the display setting and the FFT zoom factor, as shown in the table below.

Display data type	FFT zoom factor	Enlargement factor range	Display data type	FFT zoom factor	Enlargement factor range
Spectrum Phase	1	1	Time waveform	1	1, 2, 4
	2	1 , 2		2	1, 2, 4, 8
	4	1 , 2 , 4		4	1, 2, 4, 8 ,16
	8	1 , 2 , 4 , 8		8	1, 2, 4, 8 ,16, 32

When enlargement is performed, not all data can be viewed at once. Move the display area to view the desired section (☞ p. 25).
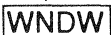
● FFT zoom factor
Indicates the FFT zoom factor.
With each push of the ⟦ZOOM⟧ key, the factor cycles through 1→2→4→8→1→2→4 etc. Changing the FFT zoom factor alters the number of samples per frame for the A/D conversion of the input signal, which in turn affects the frame time and the frequency resolution for spectrum and phase display (☞ p. 20-21).
The FFT zoom factor can also be changed from menu 1 of the analysis parameter setting mode.

● Window
Indicates the window type on which FFT (Fast Fourier Transform) of time waveform data is performed. With each push of the ⟦WNDW⟧ key, the setting cycles through "RECT" → "HANN" → "FTOP" → "RECT" etc.
　　　RECT: Rectangular window
　　　HANN: Hanning window
　　　FTOP: Flat-top window
The window type can also be changed from menu 1 of the analysis parameter setting mode. The window is used for FFT processing of the spectrum and phase display. The setting has no influence on the time waveform or PDF display.

● Trigger setting
Indicates the trigger setting. In the trigger standby condition for single or repeated trigger, the display is reversed.
The trigger setting is changed using menu 2 of the analysis parameter setting mode (☞ p. 45).

      FREE: Free run (no trigger)
      REPT: Repeated internal trigger
      SNGL: Single internal trigger
      eREP: Repeated external trigger
      eSNG: Single external trigger

● Averaging setting
Indicates the averaging processing type.
The averaging setting is changed using menu 2 of the analysis parameter setting mode (☞ p. 41).

      INST: No averaging is performed.
      LIN: Arithmetic averaging (spectrum domain)
      tLIN: Arithmetic averaging (time waveform domain)
      pLIN: Arithmetic averaging (PDF domain)
      EXP: Exponential averaging (spectrum domain)
      PEAK: Peak hold (spectrum domain)

● Frequency span
Indicates the upper frequency limit for FFT analysis. (When an external sampling signal is used, the indication "EXT" appears.)
This setting is performed with the $\boxed{UP}$ • $\boxed{DOWN}$ [FREQ SPAN] keys. An anti-aliasing filter of the same frequency as the selected frequency span is automatically activated. Each push of the $\boxed{UP}$ or $\boxed{DOWN}$ key cycles through the following upper limit settings:

      100 ↔ 200 ↔ 500 ↔ 1K ↔ 2K ↔ 5K ↔ 10K ↔ 20K ↔ 50K

The sampling frequency for A/D conversion, the sampling cycle, and the frequency span have the following relationship.

      Sampling frequency = 2.56 x Frequency span
      Sampling cycle = 1 / Sampling frequency

The frame time and the frequency resolution for spectrum and phase display are determined by the frequency span and the FFT zoom factor (☞ p. 20-21).

● Level range
  Indicates the level range.
  The range can be set with the $\boxed{\text{UP}}$ • $\boxed{\text{DOWN}}$ [LEVEL RANGE] keys (☞ p. 19).

● Units
  The display can use various units, as shown in the table below. For details, refer to the pages indicated in the table.

Display data type	X axis/Y axis	Unit display	Refer to page
Spectrum	X axis (frequency)	Hz, KCPM, ORD (internal sampling)	48
		EXT, ORD (external sampling)	
	Y axis (level)	dBV, dBVr, dBEU, dBEr (logarithmic)	35, 36
		V, Vr, EU, EUr, (linear)	
Time waveform	X axis (time)	μs, ms (internal sampling)	22
		EXTs (external sampling)	
	Y axis (level)	V, EU	35, 36
PDF	X axis (level)	V, EU	35, 36
	Y axis (amplitude probability density)	%	—
Phase	X axis (frequency)	Hz, KCPM, ORD (internal sampling)	48
		EXT, ORD (external sampling)	
	Y axis (phase)	deg (degrees)	—

Frequency units
  Hz: Hertz
  KCPM: Kilocycles per minute
  ORD: Specified frequency (except DC) taken as 1 ORD
  EXT: External sampling

Level units
  V: Normal voltage value {amplitude value ($\sqrt{2}$ x rms value)}
  Vr: Normal voltage value (rms value)
  EU: Engineering units with specified voltage value (amplitude value) taken as 1 EU
  EUr: Engineering units with specified voltage value (rms value) taken as 1 EU
  dBV: Decibel with 1 V (amplitude value) taken as reference
  dBVr: Decibel with 1 Vr (rms value) taken as reference
  dBEU: Engineering units with specified decibel value (amplitude value) taken as 0 dBEU
  dBEr: Engineering units with specified decibel value (rms value) taken as 0 dBEr

Time units
  μs: Microseconds
  ms: Milliseconds
  EXTs: External sampling

■ Pause Function

Pressing the ⌈PSE/CONT⌉ key sets the unit to the pause mode and freezes the currently displayed data.
Press the ⌈PSE/CONT⌉ key again to release the pause mode.

In the pause mode, the display parameters shown below can be changed.

```
┌─────────────────────────────────┐          SPEC
│0001                             │          PSE  ◀──── Indicates pause
│                                 │          MANU        condition
│                                 │          l o g
│                                 │          y    1
│                                 │          x    1
│          ╱╲                     │          *1
│         ╱  ╲                    │          RECT
│        ╱    ╲                   │          FREE
│   ____╱      ╲___               │          INST
│              ╲╲╲___╱╲╱╲╱╲      │          5K
│                                 │          0
│2500.0 Hz  − 66.7  dBVr          │
└─────────────────────────────────┘
```
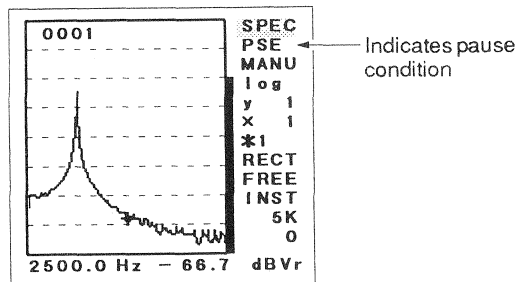
Display parameter	Operation key or menu
Display data type (SPEC/TIME/PDF/PHSE)	⌈SPEC⌋,⌈TIME⌋,⌈PDF⌋,⌈PHASE⌋
Marker position	◁·▷ [MARKER]
X axis enlargement factor	◂▸·▸◂ [X–SCALE]
X axis display area shift	◁·▷ (cursor keys), ⌈HOME⌋
Y axis enlargement factor	▲▼·▲ [Y–SCALE]
Y axis display area shift	△·▽ (cursor keys), ⌈HOME⌋
Window	⌈WNDW⌋
Level unit	Menu 1
Engineering unit function (ON/OFF)	Menu 1
Frequency unit	Menu 3
Spectrum differentiation and integration	Menu 3
Harmonic line display (ON/OFF)	Menu 3
Harmonic line base frequency	◁·▷ [MARKER] and ⌈ENTER⌋
Level scale (logarithmic/linear)	Menu 3
Grid display (ON/OFF)	Menu 3
Marker display (ON/OFF)	Menu 3
Comment input and display (ON/OFF)	Menu 4

Note: • If averaging for the spectrum domain is selected, the window cannot be changed.
   • The level range, frequency span, FFT zoom factor, averaging conditions, trigger settings, high-pass or low-pass filter settings, input coupling, and envelope processing cannot be changed.
   • When averaging processing is started, the pause condition is released.
   • If the recall mode is selected from the pause mode, the pause mode is released upon return to the analysis mode.

■ Setting the Level Range

The level (voltage) range for the input to this unit is set with the $\boxed{\text{UP}}$ • $\boxed{\text{DOWN}}$ [LEVEL RANGE] keys. (The setting cannot be changed in the pause condition.)
For time waveform and PDF display, the level range is shown in volts (amplitude value).
For spectrum and phase display, the level range display differs, depending on the level scale (logarithmic or linear) and the level unit (amplitude or rms value).

Level scale	Unit	Level range display for spectrum or phase							
Logarithmic	dBVr	-50	-40	-30	-20	-10	0	10	20
	dBV	-47	-37	-27	-17	-7	3	13	23
Linear	Vr	.003	0.01	0.03	0.1	0.31	1.0	3.16	10.0
	V	.004	.014	0.04	0.14	0.44	1.41	4.47	14.1

dBVr: Decibel with 1 Vr (rms value) taken as reference
dBV: Decibel with 1 V (amplitude value) taken as reference
Vr: rms value
V: Amplitude value ($\sqrt{2}$ x rms value)

| Spectrum | Time waveform | PDF | Phase |
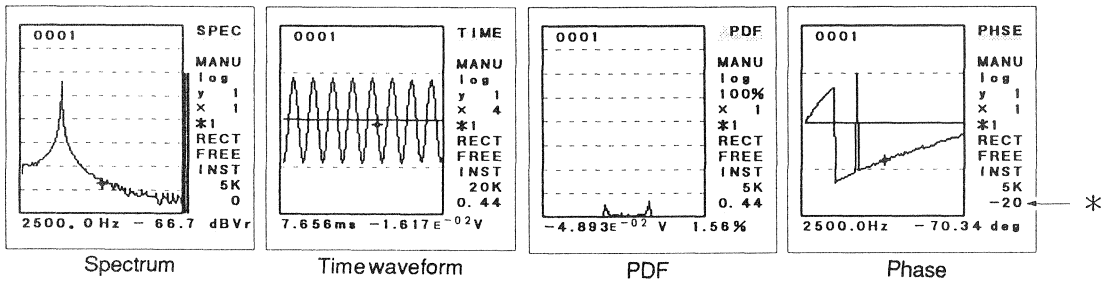
∗ : Level range

The level range setting should be performed in the spectrum or time waveform display mode. If the setting is performed in the PDF or phase display mode, the input level is not shown on the display and it is not possible to check whether the setting is appropriate.

If the signal exceeds the level range value, the indication OVER appears on the display. In such a case, set the level range to a higher value.

Over-range indication

Level range
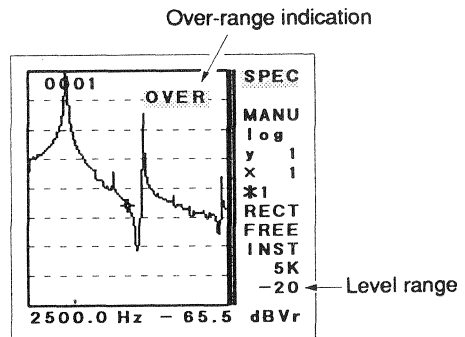
■ Setting the FFT Zoom Factor and Frequency Span

The FFT zoom factor can be set with the $\boxed{\text{ZOOM}}$ key. With each push of the key, the setting cycles through $1 \rightarrow 2 \rightarrow 4 \rightarrow 8 \rightarrow 1 \rightarrow 2 \rightarrow 4$ etc.
The upper frequency limit for FFT processing is determined by the frequency span, which is set with the $\boxed{\text{UP}} \cdot \boxed{\text{DOWN}}$ [FREQ SPAN] keys.
Each push of the $\boxed{\text{UP}}$ or $\boxed{\text{DOWN}}$ key cycles through the following upper limit settings:
$100 \leftrightarrow 200 \leftrightarrow 500 \leftrightarrow 1K \leftrightarrow 2K \leftrightarrow 5K \leftrightarrow 10K \leftrightarrow 20K \leftrightarrow 50K$

| Spectrum | Time waveform | PDF | Phase |
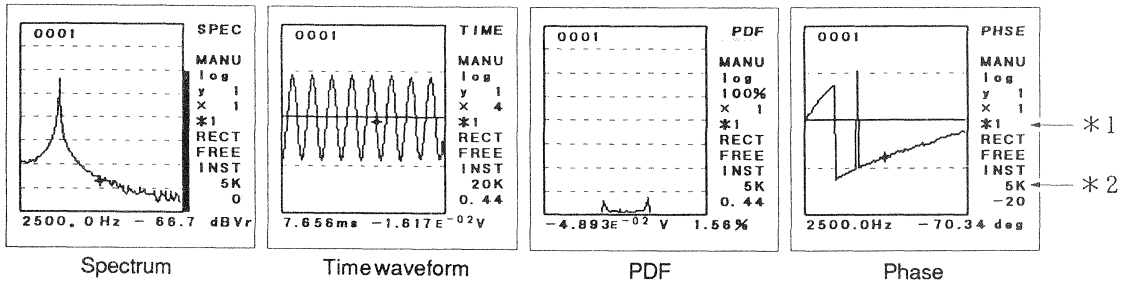
*1: FFT zoom factor
*2: Frequency span

The sampling frequency for A/D conversion (Fs), the sampling cycle (Δt), and the frequency span (Fc) have the following relationship.

$$Fs = 2.56 \times Fc \qquad \Delta t = 1 / Fs$$

The input signal is sampled according to these terms. The number of sampling points (Ns) and the number of spectrum data (NL) to be obtained with FFT is determined by the FFT zoom factor (K).

FFT zoom factor (K)	Number of sampling points(Ns)	Number of spectrum data (NL)
1	256	101
2	512	201
4	1024	401
8	2048	801

The frame time (Tk) is determined by the number of sampling points (Ns) and the sampling cycle (Δt).

$$Tk = Ns \times \Delta t$$

The basic frequency resolution (R_K) is determined by the frequency span (F_C) and the number of spectrum data (N_L).

$$R_K = F_C / (N_L - 1)$$

The table below shows these relationships for each frequency span. As the frame time and the frequency resolution for spectrum and phase display are determined by the FFT zoom factor and the frequency span, these parameters must be set to an appropriate value.

Frequency span F_C (Hz)	Sampling frequency F_S (Hz)	Sampling frequency Δt (μs)	Frame time T_K (ms)				Frequency resolution R_K (Hz)			
			T_1	T_2	T_4	T_8	R_1	R_2	R_4	R_8
50 k	128 k	7.8125	2	4	8	16	500	250	125	62.5
20 k	51.2 k	19.5312	5	10	20	40	200	100	50	25
10 k	25.6 k	39.0624	10	20	40	80	100	50	25	12.5
5 k	12.8 k	78.125	20	40	80	160	50	25	12.5	6.25
2 k	5.12 k	195.312	50	100	200	400	20	10	5	2.5
1 k	2.56 k	390.624	100	200	400	800	10	5	2.5	1.25
500	1.28 k	781.25	200	400	800	1600	5	2.5	1.25	0.625
200	512	1953.12	500	1000	2000	4000	2	1	0.5	0.25
100	256	3906.24	1000	2000	4000	8000	1	0.5	0.25	0.125

The "K" of T_K and R_K is the FFT zoom factor.

■ Reading the Marker Values

In the lower section of the display, the X axis and Y axis values for the marker position are shown. The marker position can be shifted left and right with the ◁·▷ [MARKER] keys. Keeping a key depressed will cause a continuous change.

The marker value is updated every 0.4 seconds. As this is not the same rate as the display data update, a discrepancy will occur between display data and marker value. The marker value should therefore be read after setting the unit to the pause mode. (Parameters can also be changed in the pause mode, as described on p. 18 `

● Spectrum

• Frequency (X axis)
The frequency value is shown when the internal sampling signal is used. The unit is Hz, KCPM or ORD, according to the frequency unit setting.
When an external sampling signal is used, the spectrum number at the marker position (starting from 0) is shown. The unit is EXT or ORD, according to the frequency unit setting.

> Sampling signal: See page 35.
> Frequency unit: See page 49.

Marker

| 0001 | SPEC |
| PSE |
| MANU |
| log |
| y 1 |
| x 1 |
| *1 |
| RECT |
| FREE |
| INST |
| 2K |
| -20 |

1000.0 Hz   − 39.1 dBVr

Frequency   Level

• Level (Y axis)
The spectrum level is shown. The scale is either logarithmic or linear and the selected unit is used.

> Level scale: See page 49.
> Level unit: See page 36.

When the level scale is linear, the level is shown as an exponential expression, such as $5.432E^{-01}$V. The "$E^{+/-n}$" means "$\times 10^{+/-n}$" (n: numeral).

> Example: $5.432E^{-01} = 5.432 \times 10^{-1} = 0.5432$ (V)

● Time waveform

• Time (X axis)
  The time is shown starting from the frame start
  point when the internal sampling signal is used.
  The unit is μs or ms.
  When an external sampling signal is used, the
  data number at the marker position (starting from
  0) is shown. The unit is EXTs.

• Level (Y axis)
  The level is shown. The unit is V (amplitude
  value). The "$E^{+/-n}$" means "$\times 10^{+/-n}$" (n: numeral).
  Example: $1.944E^{-01} = 1.944 \times 10^{-1} = 0.1944$ (V)

Marker

```
0001                    TIME
                        PSE
                        MANU
                        log
                        y    1
                        x    4
                        *1
                        RECT
                        FREE
                        INST
                        10K
                        0.44
3.477ms      2.467E⁻⁰¹ V
```

Time   Level
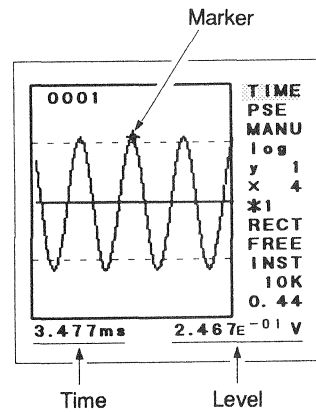
● PDF

• Level (X axis)
  The level is shown. The unit is V (amplitude
  value). The "$E^{+/-n}$" means "$\times 10^{+/-n}$" (n: numeral).
  Example: $1.888E^{-01} = 1.888 \times 10^{-1} = 0.1888$ (V)

• Amplitude probability density (Y axis)
  The amplitude probability density is shown. The
  unit is %.
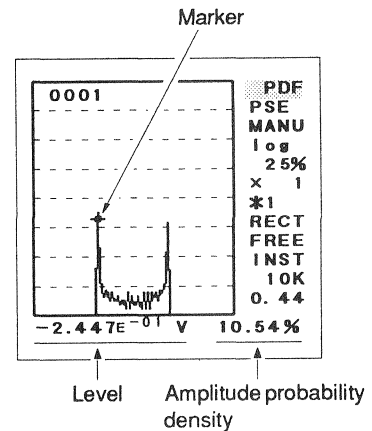
Marker

```
0001                    PDF
                        PSE
                        MANU
                        log
                        25%
                        x    1
                        *1
                        RECT
                        FREE
                        INST
                        10K
                        0.44
-2.447E⁻⁰¹ V    10.54%
```

Level   Amplitude probability
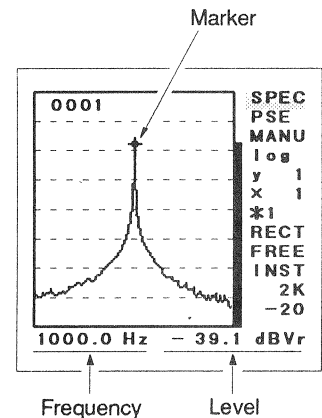   density

● Phase

• Frequency (X axis)
The frequency value is shown when the internal
sampling signal is used. The unit is Hz, KCPM or
ORD, according to the frequency unit setting.
When an external sampling signal is used, the
spectrum number at the marker position (starting
from 0) is shown. The unit is EXT or ORD, according
to the frequency unit setting.

Marker

```
0001              PHSE
                  PSE
                  MANU
                  log
                  y    1
                  x    1
                  *1
                  RECT
                  FREE
                  INST
                  10K
                  −10
5.0  kHz    −48.81 deg
```

Frequency   Phase
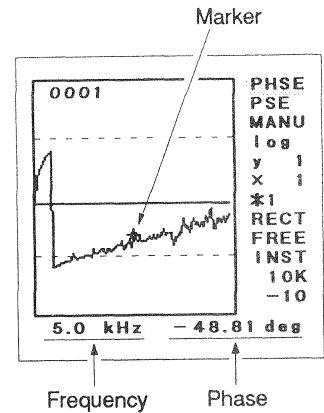
• Phase (Y axis)
The phase is shown. The unit is deg (degrees).

Note: During spectrum, time waveform, or phase display, only representative data may
       be shown on the display, depending on the FFT zoom factor and X axis enlarge
       ment setting (☞ p. 25-27). Also in such a case, the data value at any position can
       be read with the marker, but as the marker is shown on the representative data of
       the group to which it belongs, the position of the marker on screen and the actual
       marker value may be different.

■ Enlargement and Display Area Shift Along the X Axis

● Data display principles (X axis)

As explained on page 19 ("Setting the FFT Zoom Factor and Frequency Span"), the number of sampling points depends on the FFT zoom factor. Therefore, the number of data for the spectrum, time waveform, and phase display also differs. (The number of data for amplitude probability density display is always 64, regardless of the FFT zoom factor.)

FFT zoom factor	Number of sampling points	Number of data for spectrum and phase display	Number of data for time waveform display
1	256	101	256
2	512	201	512
4	1024	401	1024
8	2048	801	2048

On the screen, up to 101 data can be displayed. When the number of data is larger, the display acts as described below.

• Spectrum
If the FFT zoom factor is 1, the number of spectrum data is 101, which can be fully displayed on one screen. When the FFT zoom factor is 2 or higher, the spectrum data above the DC spectrum are clustered into groups with K/n data * each, starting from lower frequencies. The DC spectrum and the maximum spectrum data of each group (representative data) are displayed.
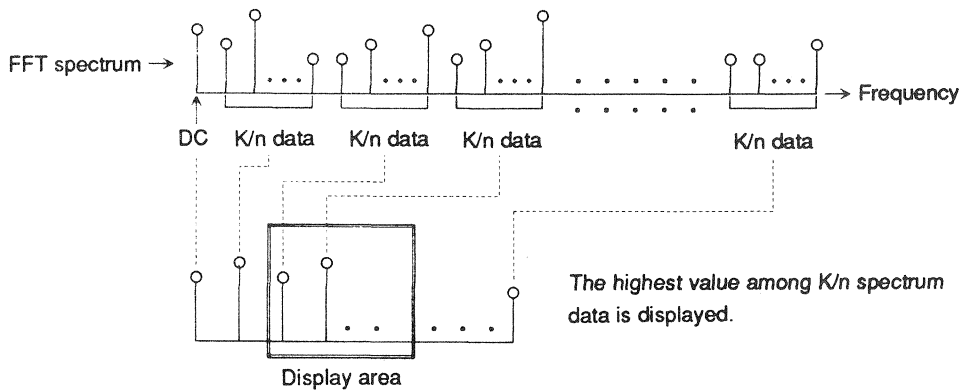
FFT spectrum →

DC   K/n data   K/n data   K/n data   K/n data

The highest value among K/n spectrum data is displayed.

Display area

* n: Enlargement factor along X axis (set with ◄► · ►◄ [X-SCALE] keys)

K: FFT zoom factor (set with ZOOM key)

When the X axis enlargement factor is 1 (n = 1), the sum of representative data is 101, and all representative data can be displayed.

When the X axis enlargement factor is 2 or higher (n = 2, n = 4, n = 8), only up to 101 of the representative data are displayed. In such a case, the display area can be shifted with the ◁·▷ (cursor keys).

• Time waveform

The time waveform data obtained by the A/D conversion process are clustered into groups with 4K/n data * each, starting from the frame start point, and the first data of each group (representative data) are displayed.

Time waveform data → ⊗○ ··· ○⊗○ ··· ○⊗○ ··· ○ · · · · · ⊗○ ··· ○ → Time

        4K/n data   4K/n data   4K/n data   4K/n data

        ⊗ : Displayed data
        ○ : Data not displayed

        * n: Enlargement factor along X axis (set with ◄►·►◄ [X-SCALE] keys)
          K: FFT zoom factor (set with ZOOM key)

When the X axis enlargement factor is 1 (n = 1), the sum of the representative data is 64. In the slots 65 to 101, the first 37 data are displayed once more (see illustration at right). The marker cannot be moved into this section.

When the X axis enlargement factor is 2 or higher (n = 2, n = 4, n = 8), only up to 101 of the representative data are displayed. In such a case, the display area can be shifted with the ◁·▷ (cursor keys).
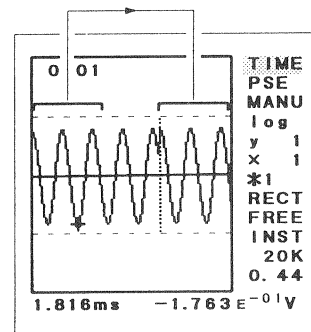
• PDF

The number of data for PDF display is always 64, regardless of the FFT zoom factor. Therefore all data can be displayed simultaneously.

• Phase

If the FFT zoom factor is 1, the number of phase data obtained by FFT processing is 101 which can be displayed simultaneously. When the FFT zoom factor is 2 or higher, the phase data above the DC phase are clustered into groups with K/n data * each, starting from lower frequencies. The DC phase and the first phase data of each group (representative data) are displayed.
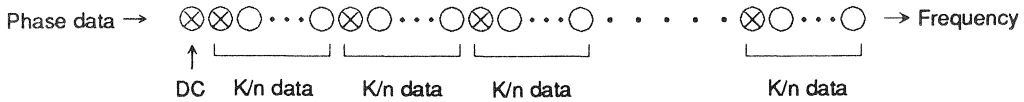
Phase data → ⊗⊗○ ··· ○⊗○ ··· ○⊗○ ··· ○ · · · · · ⊗○ ··· ○ → Frequency

DC   K/n data   K/n data   K/n data   K/n data

⊗ : Displayed data

○ : Data not displayed

* n: Enlargement factor along X axis (set with [◄►]·[►◄] [X-SCALE] keys)

K: FFT zoom factor (set with [ZOOM] key)

When the X axis enlargement factor is 1 (n = 1), the sum of the representative data is 101, and all representative data can be displayed.

When the X axis enlargement factor is 2 or higher (n = 2, n = 4, n = 8), only up to 101 of the representative data are displayed. In such a case, the display area can be shifted with the [◁]·[▷] (cursor keys).

● Setting range of FFT zoom factor and X axis enlargement factor

Display data type	FFT zoom factor	Enlargement factor range	Display data type	FFT zoom factor	Enlargement factor range
Spectrum Phase	1	1	Time waveform	1	1, 2, 4
	2	1 , 2		2	1, 2, 4, 8
	4	1 , 2 , 4		4	1, 2, 4, 8 ,16
	8	1 , 2 , 4 , 8		8	1, 2, 4, 8 ,16, 32

● Procedure for enlargement along X axis

1. Set the FFT zoom factor with the ZOOM key. This setting determines the maximum X axis enlargement factor (see table on p. 27).

2. Set the unit to the pause condition with the PSE/CONT key, if required. (In the pause condition, the FFT zoom factor cannot be changed.)

3. Use the ◁·▷ [MARKER] keys to move the marker to the center of the area to be enlarged.

4. Use the ◂▸·▸◂ [X-SCALE] keys to set the enlargement along the X axis.
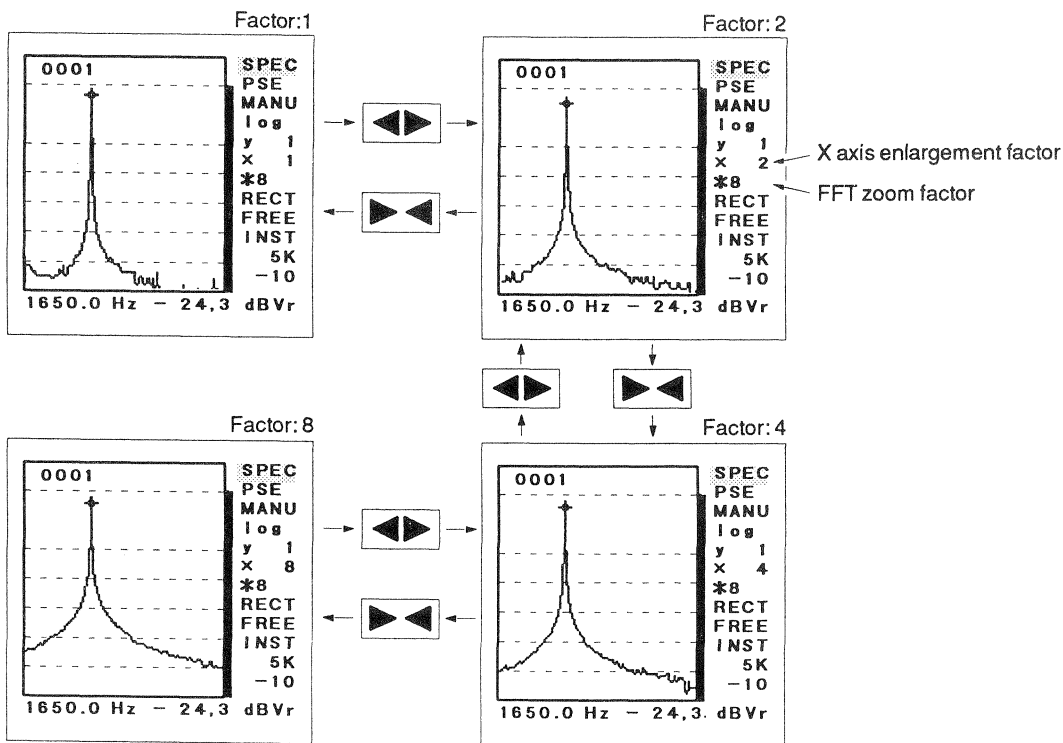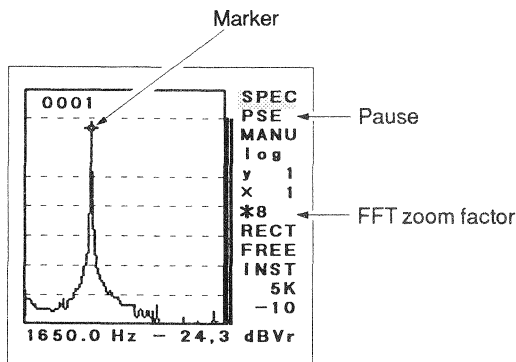
The charts show the effect of enlargement along the X axis with the spectrum display. The same procedure is used for time waveform and phase display.

● Shifting the display area along the X axis

When enlargement along the X axis is performed, not all data can be shown simultane-
ously. Use the ◁·▷ (cursor keys) to move the display area to the desired section. The
illustrations below show an example for moving the display area of a spectrum display.
The same principles apply for time waveform and phase display.

Spectrum obtained with FFT

DC

Data range

Frequency

Display area

Displayed spectrum (representative data)

Move with cursor keys
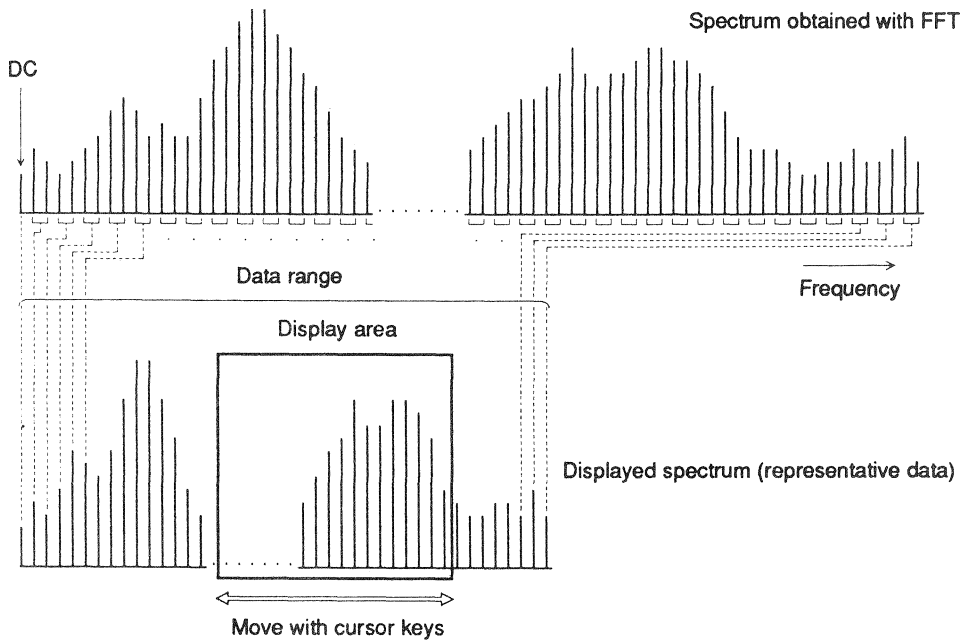
Spectrum data and display area
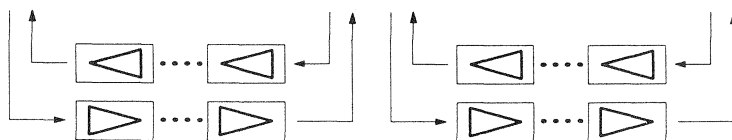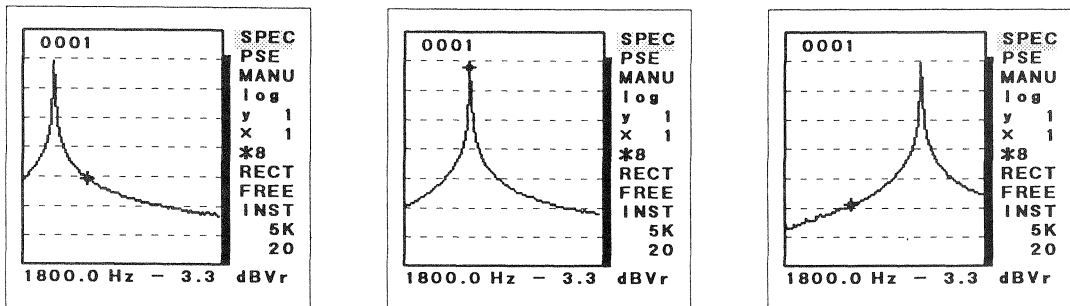
Examples for moving the display area

Pressing the |HOME| key moves the display area to the home position. If the display area was also moved along the Y axis, the home position on both the X axis and Y axis is located (☞ p. 31).

The home position on the X axis is defined as follows.
    Spectrum and phase: The DC point at the left edge of the display
    Time waveform: The frame start point at the left edge of the display

The range (number of data) by which the display area can be shifted depends on the FFT zoom factor and the X axis enlargement factor, as shown in the table below.

Display data type	FFT zoom factor	Number of shift data for each X axis enlargement factor					
		Factor: 1	Factor: 2	Factor: 4	Factor: 8	Factor: 16	Factor: 32
Spectrum Phase	1	0 (101)	—	—	—	—	—
	2	0 (101)	0-100 (201)	—	—	—	—
	4	0 (101)	0-100 (201)	0-300 (401)	—	—	—
	8	0 (101)	0-100 (201)	0-300 (401)	0-700 (801)	—	—
Time waveform	1	0 (64)	0-27 (128)	0-155 (256)	—	—	—
	2	0 (64)	0-27 (128)	0-155 (256)	0-411 (512)	—	—
	4	0 (64)	0-27 (128)	0-155 (256)	0-411 (512)	0-923 (1024)	—
	8	0 (64)	0-27 (128)	0-155 (256)	0-411 (512)	0-923 (1024)	0-1947 (2048)

Figures in brackets indicate the number of all data (representative data) which can be shown by shifting the display area.

■ Enlargement and Display Area Shift Along the Y Axis

The ⬦·⬦ [Y-SCALE] keys are used to enlarge or reduce the display along the Y axis.
⬦: Enlargement
⬦: Reduction

Note: Performing enlargement along the Y axis merely changes the display appearance but not the basic resolution of the unit itself.

The possible range of enlargement factors depends on the display data type, as shown in the table below.

Display data type	Enlargement factor range						
Spectrum	1 , 2 , 4 (logarithmic scale)						
	1 , 2 , 4 , 8 , 16 , 32 , 64 , 128 (linear scale)						
Time waveform	1 , 2 , 4 , 8 , 16 , 32 , 64 , 128						
PDF	Screen display	100%	50%	25%	10%	5%	2.5%	1%
	Enlargement factor	1	2	4	10	20	40	100

When the Y axis enlargement factor is 2 or higher, use the △·▽ (cursor keys) to move the display area to the desired section.

Pressing the HOME key moves the display area to the home position. If the display area was also moved along the X axis, the home position on both the X axis and Y axis is located (☞ p. 30).

• Spectrum

No enlargement   Enlargement   Enlargement
(Enlargement factor: 1)   Home position   Display area shifted

← Data area (dotted border)
← Display area (double border)
↕ Move with cursor keys
← Base line for enlargement and reduction

• Time waveform

No enlargement

(Enlargement factor: 1)

Enlargement

Home position

Enlargement

Display area shifted

← Display area (double border)

Move with cursor keys

← Base line for enlargement and reduction

← Data area (dotted border)

• PDF

No enlargement

(Enlargement factor: 1)

Enlargement

Home position

Enlargement

Display area shifted

← Data area (dotted border)

← Display area (double border)

Move with cursor keys

← Base line for enlargement and reduction

SETTING ANALYSIS PARAMETERS

Pressing the MENU key in the analysis mode or recall mode activates the analysis parameter setting mode, and menu 1, 2, 3, or 4 is shown. To return to the analysis mode or recall mode, press the EXIT key. When the unit is in the analysis parameter setting mode, the menus can be switched with the MENU key or the HOME key.
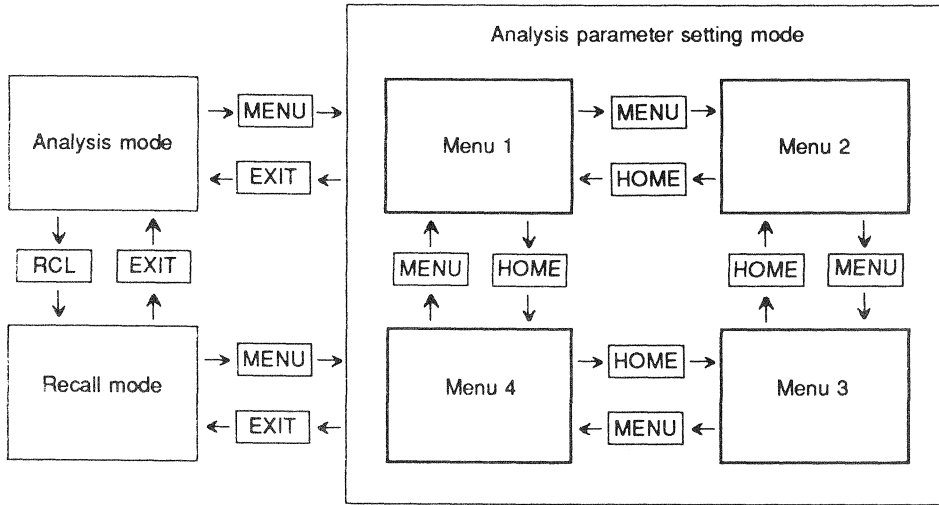
Each menu consists of an item section and a parameter section. Each section has its own cursor (reverse display).
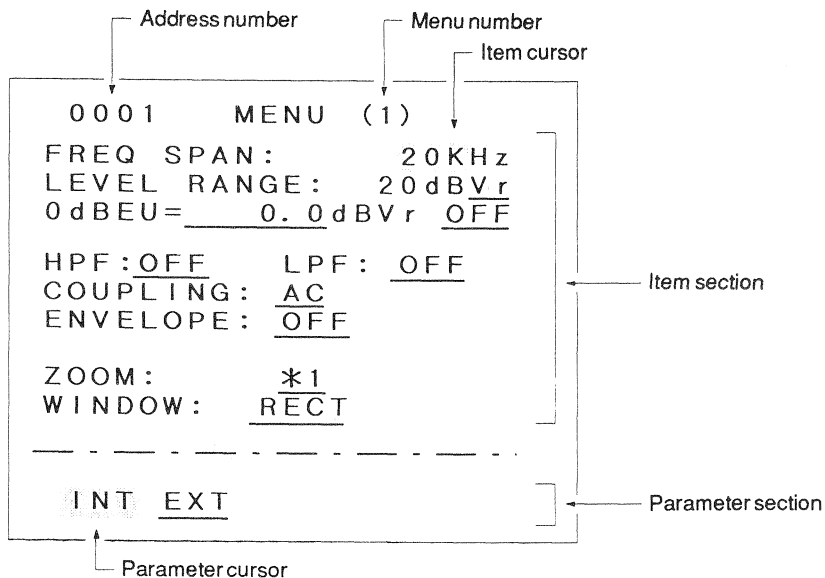
The basic procedure for setting analysis parameters is as follows.

1. Select menu 1, 2, 3, or 4 with the MENU key or HOME key.

2. Use the cursor keys ($\triangle$, $\triangledown$, $\triangleleft$, $\triangleright$ for up, down, left, right) to move the item cursor to the desired item.
   In the parameter section, the available parameters for the selected item are now shown.

3. Use the $\triangleleft \cdot \triangleright$ [MARKER] keys to move the parameter cursor to the desired parameter. For certain items, numeric input via the overlaid keypad is required.

4. Press the ENTER key. The parameter set in step 3 is entered, and the selected parameter is shown under the cursor in the item section.

5. Repeat the above steps to set other items.

6. When all parameters have been set, press the EXIT key.
   The unit reverts to the previously active mode (analysis mode or recall mode), and data are displayed according to the new parameters.

When setting parameters, the following beeper sounds are used.

One short beep   : ENTER key is pressed and parameter settings are correct.
Two short beeps : Wrong parameter setting is attempted (mainly out-of-range numeric input).
One long beep   : ENTER key is pressed at an inappropriate point.

Note: In the following cases, some items may not be set in the analysis parameter setting mode (☞ p. 60):
   • When the analysis parameter setting mode was activated from the recall mode.
   • During auto store or transient store.
   • In the pause condition.

■ Menu 1

```
  0001    MENU  (1)
 FREQ  SPAN:         20KHz        Sampling signal and frequency span
 LEVEL  RANGE:    20dBVr          Level range and unit
 0dBEU=     0. 0dBVr  OFF         Engineering units

 HPF :OFF     LPF :  OFF          High-pass and low-pass filters
 COUPLING:   AC                   Input coupling
 ENVELOPE:   OFF                  Envelope processing

 ZOOM:          *1                FFT zoom factor
 WINDOW:     RECT                 Window
 ___ _ ___ _ ___ _ ___

   INT  EXT
```
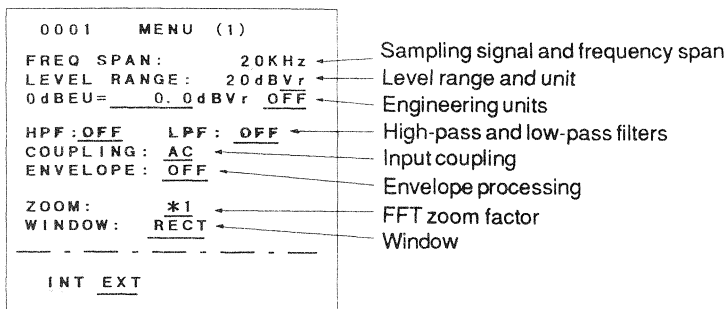
● Sampling Signal and Frequency Span (FREQ SPAN)

This sets the type of sampling signal (internal/external) to be used for A/D conversion of the input signal, and the frequency span (upper frequency limit for FFT analysis). When the internal sampling signal is selected, the sampling frequency is also determined by this setting. (For details, refer to p. 20-21).

```
 FREQ SPAN:   20KHz

 ___ _ ___ _ ___ _ ___

    INT   EXT
```
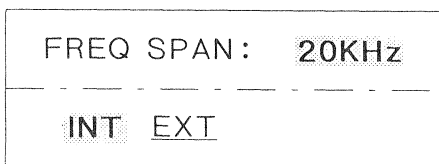
(Figures show frequency span and anti-aliasing filter for internal sampling signal.)

INT: Internal sampling signal
    After selecting "INT", use the UP • DOWN [FREQUENCY SPAN] keys to set the frequency span (100, 200, 500 Hz, 1, 2, 5, 10, 20, 50 kHz). An anti-aliasing filter of the same frequency is automatically activated.

EXT: External sampling signal
    Sampling is performed using an external sampling signal (TTL level) supplied at the external sampling signal input jack.
    The setting of the anti-aliasing filter is the same as the frequency span selected before "EXT" was selected. Use the "INT" setting to first set the desired anti-aliasing filter frequency before selecting "EXT".

Note : • The frequency of the external sampling signal should be over 2.56 times higher than the frequency of the anti-aliasing filter (frequency span), but not higher than 128 kHz. If this precaution is not observed, the following phenomena will occur:
        1) Aliasing
        2) The first instantaneous data in the arithmetic averaging mode (LIN) or peak hold mode (PEAK) will not be reliable.

3) When using the pretrigger function, the number of sampling points before the trigger point is limited and normal sampling is not possible.

4) When the frequency of the anti-aliasing filter is 10, 20, or 50 kHz, sampling may not be carried out continuously.

• Supply the external sampling signal to the SA-77 before selecting "EXT". If "EXT" is selected while the external sampling signal is not yet input, or if the frequency of the external sampling signal is changed, sampling lock-up occurs. In such a case, press the RESET button.

● Level Range and Unit (LEVEL RANGE)

This sets the level range and the level unit for spectrum display.

```
LEVEL RANGE:    20dB Vr          LEVEL RANGE:    10.0 Vr
---------------------|-------      ---------------------|------
  Vr   V                            Vr   V
         Level range──┘  └─Unit            Level range──┘  └─Unit
```

Logarithmic level scale   Linear level scale
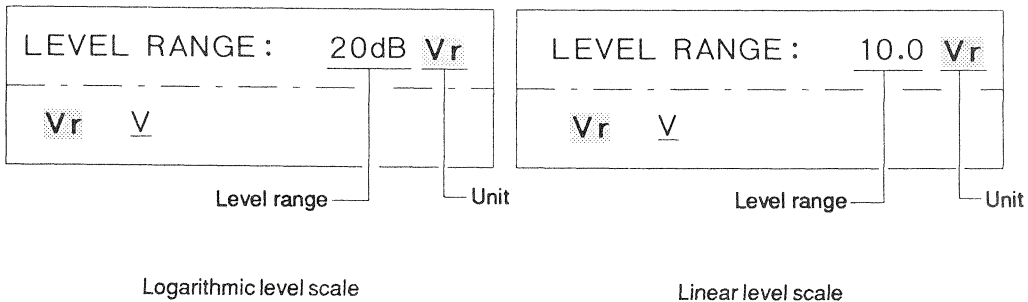
• Level range
Set with the UP • DOWN [LEVEL RANGE] keys. Each push of a key changes the level by one step.
The setting range depends on the level scale (☞ p. 49) and the level unit.

Level scale	Unit	Level range							
Logarithmic	dBVr	-50	-40	-30	-20	-10	0	10	20
	dBV	-47	-37	-27	-17	-7	3	13	23
Linear	Vr	0.003	0.01	0.031	0.1	0.316	1.0	3.162	10.0
	V	0.004	0.014	0.044	0.141	0.447	1.414	4.472	14.14

dBVr: Decibel with 1 Vr (rms value) taken as reference
dBV: Decibel with 1 V (amplitude value) taken as reference

• Unit
Sets the level unit for spectrum display. The level unit for time waveform and PDF display is always V (amplitude value).
Vr: rms value
V: amplitude value ($\sqrt{2}$ x rms value)

Note: When input coupling is DC, the level range cannot be set to less than 0.044 V (0.031 Vr, –27 dBV, –30 dBVr).

● Engineering Units (0dBEU/1EU)

Inputs EU value and selects whether engineering units are used for level display.

Select with $\boxed{\triangleleft}$ · $\boxed{\triangleright}$ (cursor keys)

0dBEU= 0.0 dBVr   OFF
OFF   ON

1EU=1.00E^{+0} Vr   OFF
OFF   ON

EU value ———   ——— Engineering unit
                                          activation

0dBEU= 0.0 dBVr   OFF
+000.0

1EU=1.00E^{+0} Vr.   OFF
1.00E^{+0}

Logarithmic level scale   Linear level scale
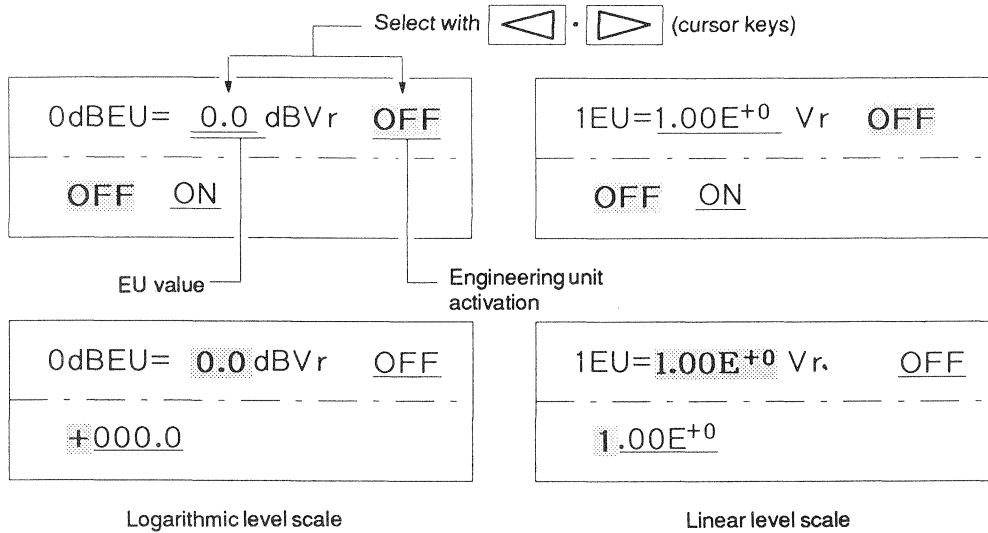
• EU value
Input the level to be used as 0 dBEU or 1 EU with the numeric keypad. The input format differs, depending on whether the level scale is logarithmic or linear.

Logarithmic type
0 dBEU = nnn.n dBVr (or dBV)
$-160.0 \leq nnn.n \leq 179.9$
(The energy corresponding to 1 EU is defined as 0 dBEU.)

Linear type
1 EU = n.nnE^m Vr (or V)
Mantissa: $1.00 \leq n.nn \leq 9.99$
Exponent: $-8 \leq m \leq 8$ ($10^{-8} \leq E^m \leq 10^8$)

When the level unit is changed from Vr to V, the above range may be exceeded.
The ranges shown above apply only for input and not for display.

• Engineering unit activation
This setting determines whether engineering units are used for the display or not.
OFF: Engineering units not used (level unit is Vr, V, dBVr, or dBV)
ON: Engineering units are used.

• Relationship between logarithmic EU value and linear EU value
Entered logarithmic EU values and linear EU values are mathematically transformed (approximation) by the SA-77. However, for optimum accuracy, it is preferable to input the units in the same notation that is to be used.

Logarithmic value transformation equation:
$$Y = 20 \log X$$
$$X = 10^{Y/20}$$
Where
X: linear EU value
Y: logarithmic EU value

- Change of EU values due to conversion of level units (Vr/V)
  When X is set as a linear EU value with the Vr unit, and the unit is then changed into V, the EU value becomes $\sqrt{2}$ X. Reversely, when Y was set as a linear EU value with the V unit, and the unit is changed into Vr, the EU value becomes $(1/\sqrt{2})$Y.

  EU value with Vr unit: X $\xrightarrow{\text{Unit conversion Vr to V}}$ EU value with V unit: $\sqrt{2}$X

  EU value with V unit: Y $\xrightarrow{\text{Unit conversion V to Vr}}$ EU value with Vr unit: $(1/\sqrt{2})$Y

- Use of the engineering units
  Engineering units are used to match the changes of a physical phenomenon under examination to the changes of an electrical signal. As an example, consider the case when an accelerometer with a sensitivity of 48 mV/G is used to obtain the acceleration spectrum of machine vibrations, and a gravitational acceleration signal of 2.0 G yields a spectrum display value of 9.6×10^{-2} Vr. In such a case, selecting 1 EU = $4.8E^{-2}$ Vr makes it possible to directly read the spectrum in gravitational acceleration values.

● High-pass and Low-pass Filters (HPF/LPF)

Select the use of high-pass and low-pass filters for the input signal.


```
                    Select with  [ ◁ ] · [ ▷ ]  (cursor keys)

  ┌─────────────────────────┐    ┌─────────────────────────────┐
  │  HPF : OFF   LPF : OFF   │    │   HPF : OFF   LPF : OFF      │
  │ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ │    │ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ │
  │   OFF  5  50  1K         │    │   OFF  1K  5K  10K           │
  └─────────────────────────┘    └─────────────────────────────┘
      └ High-pass filter  └ Low-pass filter
```
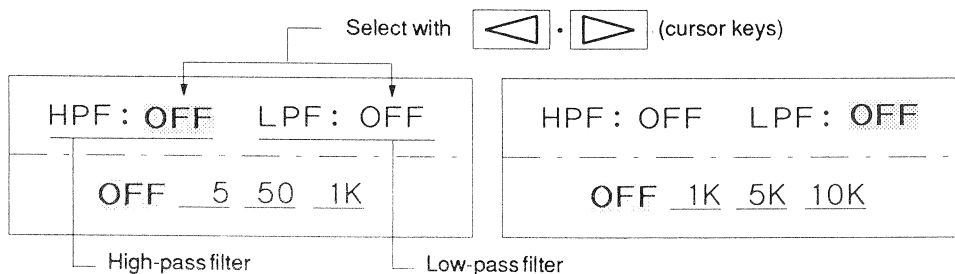
High-pass filter settings: Low-pass filter settings:
         OFF: No filter   OFF: No filter
          5: 5 Hz   1K: 1 kHz
         50: 50 Hz   5K: 5 kHz
         1K: 1 kHz   10K: 10 kHz

● Input Coupling (COUPLING)

Sets the type of input coupling.

```
COUPLING:    AC
─ ─ ── ─ · ── · ── ─ · ─
   AC   DC
```

AC: AC coupling (0.5 Hz high-pass filter inserted)
DC: DC coupling

Note: When DC input coupling is selected, the following items are set automatically.
High-pass filter: OFF
Low-pass filter: OFF
Envelope processing: OFF
Level range: If setting is less than 0.044 V (0.031 Vr, –27 dBV,
                                  –30 dBVr), setting is changed to 0.044 V

● Envelope Processing (ENVELOPE)

Selects whether envelope processing is used or not (ON or OFF).

```
ENVELOPE:   OFF
─ ─ ── ─ · ── · ── ─ · ─
   OFF   ON
```

When envelope processing is activated, absolute detection (reversal of negative signals into positive signals) is carried out on the input signal before A/D conversion. This is useful for example to analyze shock vibrations caused by damaged bearings of rotational machinery. The cycle of shock vibrations caused by damaged bearings varies depending on the damaged location. Often the vibrations contain high-frequency components ranging from several kilohertz to several tens of kilohertz. If such a signal is analyzed without performing absolute detection, the cycle will not be apparent from the spectrum. Absolute detection makes it possible to discern the cycle (frequency), as shown in the illustrations on the next page. Normally, for such measurements, a high-pass filter with a cutoff frequency of several kilohertz is used to remove low-frequency components.

Input signal after high-pass filter
(no envelope processing)

→ Time

FFT

Level

Spectrum

→ Frequency

Input signal after high-pass filter
(with envelope processing)

Ts

→ Time

FFT

Level

$\frac{1}{Ts}$

Spectrum

→ Frequency
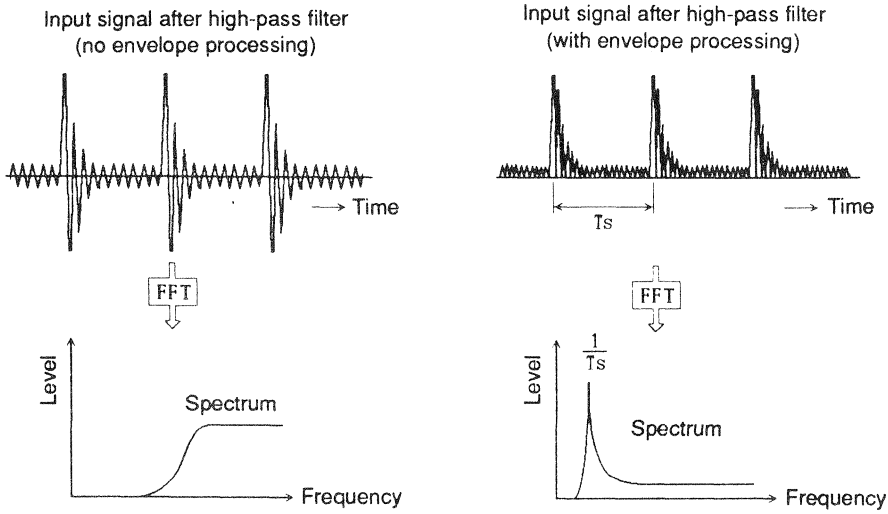
● FFT Zoom Factor (ZOOM)

Sets the FFT zoom factor (1, 2, 4, or 8).

ZOOM :   *1

*1   *2   *4   *8
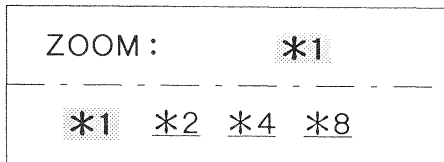
The FFT zoom factor can also be set with the ZOOM key.

● Window (WINDOW)

Selects the window type to be used for FFT of time waveform data.
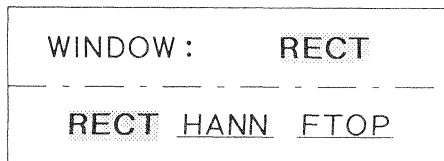
WINDOW :   RECT

RECT HANN FTOP

RECT: Rectangular window
HANN: Hanning window
FTOP: Flat-top window

The window type can also be set with the WNDW key.

■ Menu 2

```
 0001     MENU  (2)

AVERAGE  DOMAIN:  SPEC          Averaging domain
         MODE:    INST          Averaging mode           Averaging conditions
         N  :    ****           Number of averaging counts

TRIGGER  SOURCE:  INT           Trigger source
         MODE:    FREE          Trigger mode
         LEVEL:   +0/8          Trigger level            Trigger conditions
         SLOPE:    +            Trigger slope
         N  :+    0             Trigger point

 —  -  -  -  —  -  —  -  —

 SPEC  TIME  PDF
```
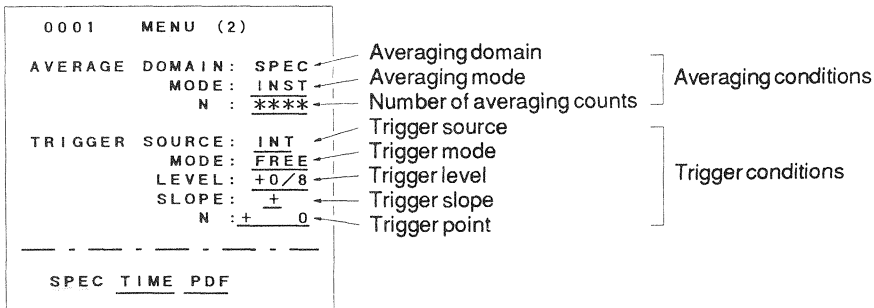
● Averaging Domain (AVERAGE DOMAIN)

Sets the domain to be covered by averaging.

```
    AVERAGE DOMAIN: SPEC

    SPEC  TIME   PDF
```
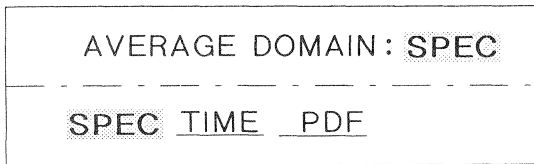
   SPEC: Spectrum domain (spectrum arithmetic averaging, exponential averaging,
          peak hold)
   TIME: Time waveform domain (time waveform arithmetic averaging)
   PDF: PDF domain (arithmetic averaging of amplitude probability density
          from one frame of time waveform data)

● Averaging Mode (MODE)

Sets the averaging mode.

```
              MODE: INST

    INST   LIN  EXP  PEAK
```
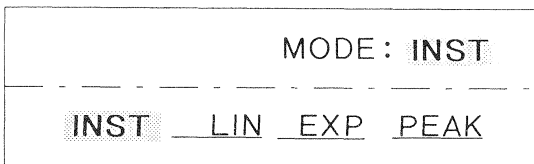
   INST: No averaging processing
   LIN: Arithmetic averaging
   EXP: Exponential averaging
   PEAK: Peak hold for each spectrum line

Note:　• "EXP" and "PEAK" can be selected only when the averaging domain is set to "SPEC".
　　　　• When single trigger ("SNG") is selected, averaging cannot be carried out. Reversely, when averaging is activated, single trigger cannot be selected.

● Number of Averaging Counts (N)

Sets the number of averaging counts. The number is input using the numeric keypad.

```
                        N :      10

  0 010
```

The meaning of "N" differs, depending on the averaging mode, as shown in the table below.

Averaging mode (MODE)	Averaging count (N)
No averaging (INST)	No count (display: ✳✳✳✳)
Arithmetic averaging (LIN)	Number of frames for arithmetic averaging $Y_n = \sum_{n=1}^{N} X_n / N$　　　　Y_n: Average data Setting range: $2 \leq N \leq 8000$　　X_n: Instantaneous data
Exponential averaging (EXP)	Weighting factor for exponential averaging $Y_n = Y_{n-1} - (Y_{n-1} - X_n) / N$ Setting range: $2 \leq N \leq 8000$
Peak hold (PEAK)	Number of frames for peak hold Y_n is the maximum value of the data in N frames (X_1, X_2, X_3, …X_n) Setting range: $2 \leq N \leq 8000$, $N = 0$ (Average count = ∞)

● Averaging Procedure

1. After all parameters for averaging have been set, press the [EXIT] key to return to the analysis mode.

2. Press the [STRT] key.
   Previously stored averaging data are cleared, and averaging processing starts. For arithmetic averaging and peak hold, the operation stops automatically when the preset averaging count is reached. For exponential averaging, processing continues regardless of the averaging count.
   To temporarily interrupt averaging processing, press the [PSE/CONT] key. To resume the operation, press the [PSE/CONT] key again.
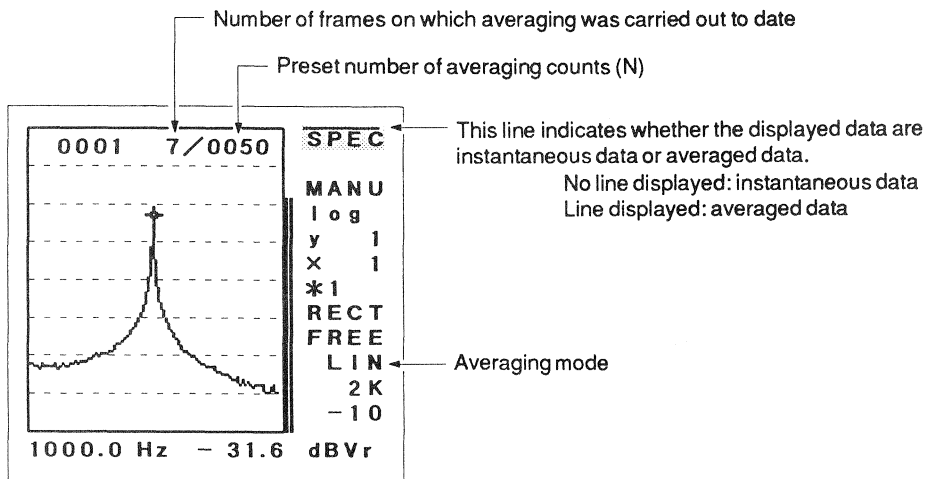
When one of the following item settings is changed, averaging is restarted:

Averaging conditions
Frequency span
Input coupling
Level range
Filter
Envelope processing
Trigger conditions
FFT zoom factor
Window (averaging of spectrum domain only)

● Relationship Between Averaging Settings and Display Data

Averaged data can be displayed either while averaging is being carried out or after the process is finished. Use the AVE key to switch between instantaneous data display and averaged data display.

```
┌─────────────────────┐   ← AVE ←   ┌─────────────────────┐
│ Instantaneous data  │             │   Averaged data     │
│       display       │   → AVE →   │       display       │
└─────────────────────┘             └─────────────────────┘
```
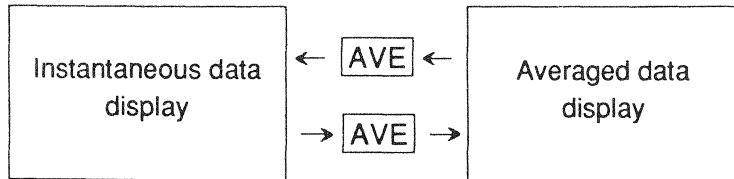
When showing instananeous data, the spectrum, time waveform, PDF, or phase can be displayed. The indication at the top right of the display is SPEC (spectrum), TIME, PDF, or PHSE (phase).

When showing averaged data, the data on the display depend on the averaging domain and the averaging mode, as shown in the table below.

Averaging domain (DOMAIN)	Averaging mode (MODE)	Displayed averaged data	Indication at top right of screen
Spectrum	Arithmetic averaging Exponential averaging Peak hold	Spectrum	SPEC
Time waveform	Arithmetic averaging	Time waveform	TIME
		Spectrum *	SPEC
		Amplitude probability density *	PDF
		Phase *	PHSE
PDF	Arithmetic averaging	Amplitude probability density	PDF

★ : Data calculated from the averaged time waveform data (not averaged data of spectrum, amplitude probability density, or phase directly)

During arithmetic averaging of time waveform data, the spectrum (SPEC), amplitude probability density (PDF), and phase (PHASE) calculated from these data can be displayed.

● Trigger Source (TRIGGER SOURCE)

Sets the type of trigger.

```
TRIGGER SOURCE :     INT

INT  EXT
```

INT: Internal trigger (input signal serves as trigger)
EXT: External trigger (external trigger signal is supplied)

When the EXT setting is chosen, a TTL level trigger signal must be connected to the external trigger signal input jack (see connection chart on p. 6).
The external trigger function always uses the falling edge of the signal. The trigger level and trigger slope settings of the SA-77 have no effect when the external trigger function is selected.

● Trigger Mode (MODE)

Sets the trigger mode.

```
MODE : FREE

FREE  REPT  SNGL
```

FREE: Free run (no trigger)
REPT: Repeated trigger
         Trigger is activated every time the level and slope conditions are
         fulfilled.
SNGL: Single trigger
         Trigger is activated once when the level and slope conditions are
         fulfilled.

When wishing to use the trigger function again after the single trigger has been activated, press the STRT button.

Note: When single trigger is selected, averaging processing cannot be carried out.
      Reversely, when averaging is activated, the single trigger cannot be selected.

● Trigger Level (LEVEL)

Sets the input signal level to be used as trigger level when internal trigger is selected. When the input signal becomes ±n/8 of the level range, the trigger is activated. The value of +n or –n is input with the numeric keypad. (n: 0, 1, 2, 3, 4, 5, 6, 7)

```
                LEVEL : +0/8
 ─────────────────────────────────────
  +0/8
```

Note: For the following combinations of trigger slope and trigger level, setting from the menu is possible, but the trigger function is not actually activated.
Trigger slope + and trigger level –7/8
Trigger slope – and trigger level +7/8

● Trigger Slope (SLOPE)

Sets the trigger slope for the internal trigger.

```
                SLOPE :    +
 ─────────────────────────────────────
   –  +
```

+: Trigger is activated at rising edge of input signal
–: Trigger is activated at falling edge of input signal

● Trigger Point (N)

Sets the time relation of the trigger point and the frame start point in number of sample points (N). A negative value for N results in pre-trigger function, and a positive value in post-trigger function. The value for N is input with the numeric keypad.

```
                   N : +    0
 ─────────────────────────────────────
  +0000
```

The setting range for N is limited by the FFT zoom factor, as shown in the table below.

FFT zoom factor	Setting range of N	FFT zoom factor	Setting range of N
1	$-255 \leq N \leq +2000$	4	$-1023 \leq N \leq +2000$
2	$-511 \leq N \leq +2000$	8	$-2000 \leq N \leq +2000$

Under no circumstances will frames overlap.

Example for trigger point setting and frame position

N = 0

Trigger point

N = -100
Pre-trigger

Sample point number: 100

N = +100
Post-trigger

Sample point number: 100
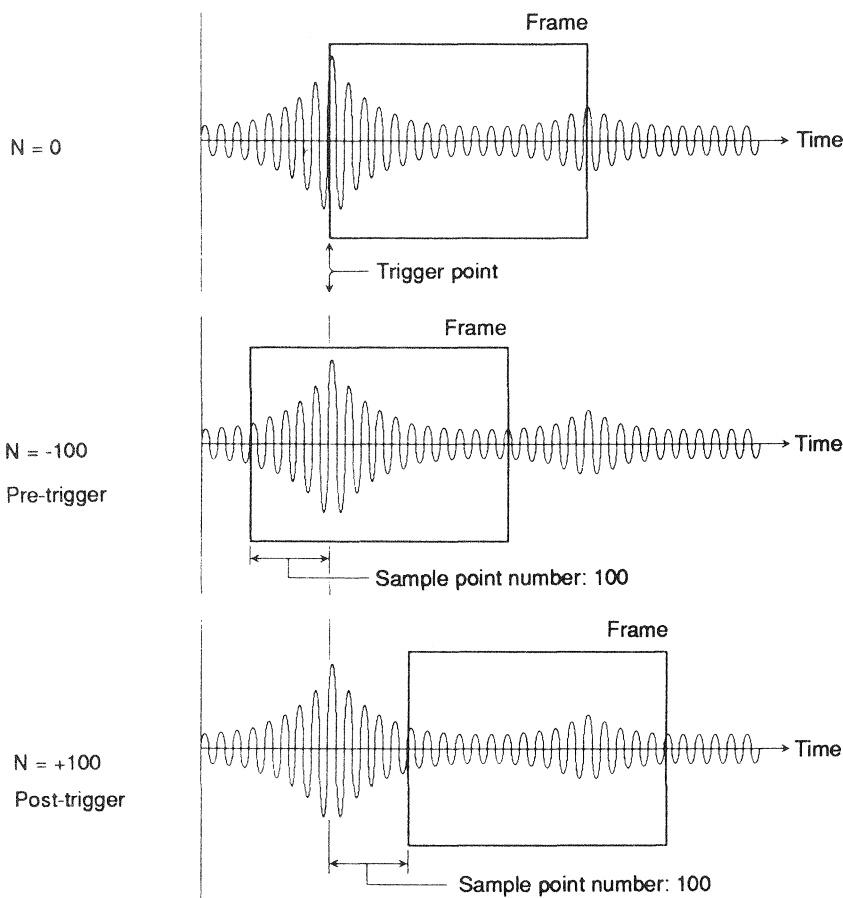
■ Menu 3

```
  0001     MENU  (3)          ── Spectrum differentiation and integration
SPEC OPE:  OFF ◄──────────── Level scale (Y axis scale for spectrum display)
  Y-AXIS:  log ◄──
  X-AXIS:  Hz ◄──
                           ── Frequency unit (X axis unit for spectrum and phase display)
DISPLAY  Y-GRID:   ON
HARMONIC  LINE:   OFF
   MARKER  LINE:   ON
                           ── Grid display
BAUD  RATE :  4800         ── Harmonic line display
POWER  SAVE:  OFF          ── Marker line display
────────────────────── ── Baud rate
  OFF  -1/ω²  1/jω  jω  -ω² ── Auto power-off function
```

● Spectrum Differentiation and Integration (SPEC OPERATION)

Selects differentiation or integration functions for spectrum display.

```
 SPEC OPE :   OFF
──────────────────────────────
 OFF  - 1 /²  1/ jω   jω  -ω²
```

OFF: No differentiation or integration
$-1/\omega^2$: Double integral
$1/j\omega$:   Integral
$j\omega$:   Differential
$-\omega^2$:   Two-step differential

Differentiation and integration are carried out by arithmetic approximation of $1/j\omega$ (integral), $-1/\omega^2$ (double integral), $j\omega$ (differential), and $-\omega^2$ (two-step differential) of the frequency domain of the spectrum, not of the time waveform.

The result of differentiation and integration is shown by the marker value. The displayed spectrum does not change (spectrum without differentiation and integration is shown).

```
 0001              SPEC
                   PSE
                   MANU
                   log
                   y    1
                   x    1
                   *1
                   RECT
                   FREE
                   INST
                    2K
                   -10
 1000.0 Hz - 30.9 dBVr
```

Integration (1/jω)

```
 0001              SPEC
                   PSE
                   MANU
                   log
                   y    1
                   x    1
                   *1
                   RECT
                   FREE
                   INST
                    2K
                   -10
 1000.0 Hz  -106.9 dBVr
```
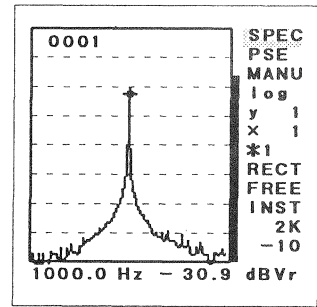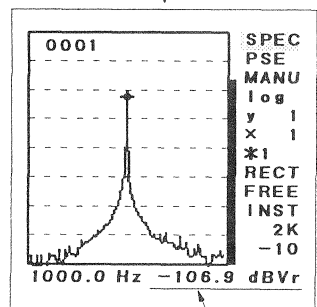
Integration value

Note: For DC component, differentiation and integration are not carried out. For data collected with an external sampling signal, OFF setting is chosen automatically, regardless of the differentiation and integration setting.

● Level Scale (Y-AXIS)

Selects the type of Y axis level scale for spectrum display. The level scale for time wave-
form and PDF display is always linear, regardless of this setting.

```
Y-AXIS :      log
- - - - - - - - - - - -
log  lin
```

      log: Logarithmic scale
      lin: Linear scale

Note: The input format of engineering units (☞ p.37), level range (☞ p.36), and the
      level range display for spectrum and phase display (☞ p.17) all depend on
      whether the scale is logarithmic or linear.

● Frequency Unit (X-UNIT)

```
X-AXIS :      Hz
- - - - - - - - - - - -
HZ  KCPM  ORD
```

      Hz: Hertz
      KCPM: Kilocycles per minute
      ORD: Specified frequency (except DC) taken as 1 ORD

  · Using ORD units
     1. Set the frequency unit to "ORD" with menu 3.
     2. Press the ⎢EXIT⎥ key to return to the analysis mode or the recall mode.
     3. Use the ◁·▷ [MARKER] keys to move the marker to the frequency position
       you want to use as "1 ORD".
     4. Press the ⎢ENTER⎥ key.
       The frequency at the marker position becomes "1 ORD".

After setting the ORD frequency as described above, frequency values can be read in
ORD. If for example 100 Hz was set as 1 ORD, 50 Hz will be 0.5 ORD, 500 Hz will be 5
ORD, etc.

● Grid Display (Y-GRID)

Sets the grid display to ON or OFF.

```
┌─────────────────────────────────────┐
│                                     │
│  DISPLAY Y-GRID:    ON              │
│                                     │
│  ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─   │
│                                     │
│    OFF   ON                         │
│                                     │
└─────────────────────────────────────┘
```

The type of grid display depends on the display data. For spectrum and PDF display, seven grid lines are displayed, which divide the Y axis into eight equal sections.

Grid lines

Spectrum display   PDF display
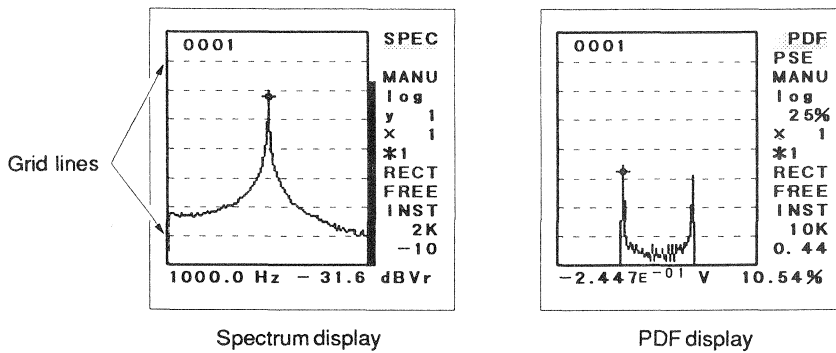
For time waveform and phase display, two grid lines are displayed. Together with the base line, these divide the Y axis into four equal sections.

Grid lines ──
Base line ──
Grid line ──

Time waveform display   Phase display
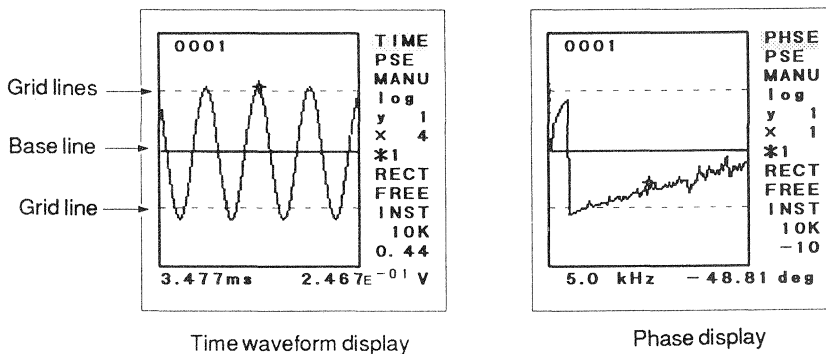
● Harmonic Line Display (HARMONIC LINE)

Selects whether harmonic lines are shown during spectrum and phase display or not.

```
HARMONIC LINE :    OFF
─────────────────────────
OFF   ON
```

OFF: Harmonic lines are not shown.
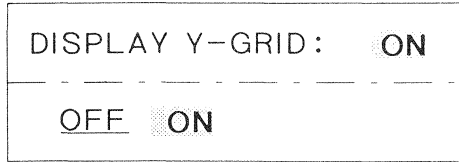ON: Harmonic lines are shown (up to 8th order).

• Using the harmonic line display
   1. Set the harmonic line item to "ON" with menu 3.
   2. Press the |EXIT| key to return to the analysis mode or the recall mode.
   3. Use the |◁|·|▷| [MARKER] keys to move the marker to the frequency position
      you want to use as base frequency.
   4. Press the |ENTER| key
   The frequency at the marker position becomes the base frequency, and the first-
      order harmonic line is shown at this position.

1st-order harmonic line
2nd-order...8th-order
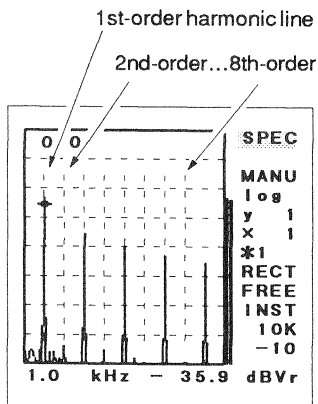
● Marker Line Display (MARKER LINE)

Selects whether the marker line is displayed (ON) or not (OFF). This setting only affects the marker line. The marker value is always shown in the lower part of the screen.

```
MARKER LINE :      ON
-- -- -- -- -- -- -- -- --
 OFF   ON
```

● Baud Rate (BAUD RATE)

Sets the baud rate for the built-in RS-232-C interface (unit: bps). For data communication with a computer, the baud rate must be set to the same value at both ends.

```
BAUD RATE :      4800
-- -- -- -- -- -- -- -- --
 1200 2400 4800 9600
```

● Auto Power-off Function (POWER SAVE)

Selects whether the auto power-off function is used or not.

```
POWER SAVE :      OFF
-- -- -- -- -- -- -- -- --
 OFF   ON
```

OFF: Unit does not turn itself off automatically.
Press the [PWR] key to turn the unit off after use.
ON: Unit turns itself off automatically if no key was operated for about 20 minutes. This helps to conserve battery power. The unit may of course also be turned off at any time by pressing the [PWR] key.

■ Menu 4

```
  0001     MENU  (4)
PANEL
   STORE  :  1 ◄────────────── Analysis parameter store ┐
   RECALL:  1 ◄────────────── Analysis parameter recall ┘ Panel memory
MASS  MEMORY
   STORE_TYPE:  MANU ◄──────── Store type              ┐
   CLEAR:    1..      1 ◄────── Memory clear            │
   STEP:   △   1 ◄───────────── Step count              ├ Mass memory
                                                        │
CMNT:            OFF ◄───────── Comment                 ┘
─── - ─── - ─── - ─── - ───

   1
```
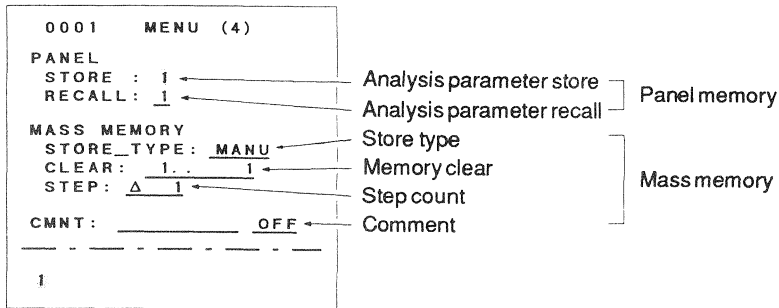
Panel memory: The SA-77 incorporates a panel memory which can store four sets of analysis conditions. By storing often used settings in the unit, setup time can be reduced. Note that the following parameters are not stored in the panel memory:
- Store type of mass memory, step count, memory address
- RS-232-C interface baud rate
- Auto power-off (power save) setting

Mass memory: In the mass memory, analysis result data are stored. This part of the menu serves to set the store type and to clear stored data.

● Analysis Parameter Store (STORE)

This item serves to select a memory number and store the currently set analysis conditions in that memory.

```
 STORE :  1
─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─        (The number indicates the memory number.)
 1
```
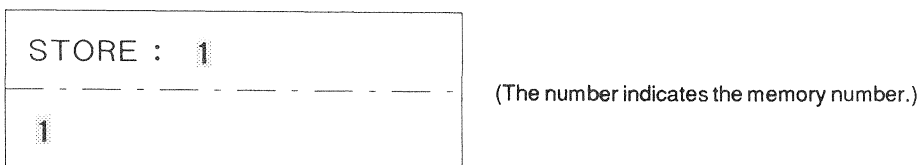
1. Set the analysis parameters in the analysis mode and with menus 1, 2, 3, and 4.
2. Move the item cursor to "STORE" on menu 4.
3. Enter the desired panel memory number (1-4) with the keys of the numeric keypad.
4. Press the |ENTER| key.
   A short beep confirms that the settings are stored in the selected panel memory.

● Analysis Parameter Recall (RECALL)

This item serves to recall a set of stored analysis conditions and use it to display data.

```
RECALL : 1
─────────────────────
  1
```
(The number indicates the memory number.)

1. Move the item cursor to "RECALL" on menu 4.
2. Enter the desired panel memory number (1-4) with the keys of the numeric keypad.
3. Press the $\boxed{\text{ENTER}}$ key.
   A short beep confirms that the stored settings are now used to display data.

Note: If no analysis conditions are stored in a panel memory number, that number cannot be selected.

● Store Type (STORE TYPE)

This item serves to select the type of function to be used to store data in the mass memory. Choose one of the three available types, depending on the kind of data to be stored and the purpose of the stored data. (For details on the store procedure, refer to pages 63-70.)

```
STORE_TYPE :   MANU
──────────────────────
  MANU  AUTO  TRSN
```

MANU: Manual store
      One frame of data is stored in a specified address. If that address already contains manually stored data, the old data in that address are cleared and replaced by the new data. (Data in other addresses are not affected.) If the address contains data stored by auto store or transient store, all data (also in other addresses) are cleared, and then the data are stored in the specified address.
      The kind of stored data depends on the currently displayed type of data.

Displayed data		Stored data
Instantaneous data	Spectrum	Instantaneous time waveform data
	Time waveform	
	Amplitude probability density	
	Phase	
Averaged data	Spectrum	Averaged spectrum data
	Time waveform *	Averaged time waveform data
	Amplitude probability density	Averaged amplitude probability density data

★: Including display of spectrum, amplitude probability density,
or phase derived from averaged time waveform data.

If the stored data are time waveform data, the spectrum, amplitude probability density, or phase derived from those data can be displayed after recall.

AUTO: Auto store
Data are.stored in the mass memory continuously, starting from address 1. Any previously stored data (including data stored with manual store or transient store) are cleared and replaced by the new data. The kind of stored data depends only on the selected averaging processing conditions, it is not influenced by the data that are currently shown on the display of the SA-77.

Averaging domain	Averaging mode	Stored data
————	No averaging	Instantaneous time waveform data *1
Spectrum	Arithmetic averaging	Arithmetic averaged spectrum data *2
	Exponential averaging	Exponential averaged spectrum data *3
	Peak hold	Spectrum peak data *4
Time waveform	Arithmetic averaging	Arithmetic averaged time waveform data *2
PDF	Arithmetic averaging	Arithmetic averaged amplitude probability density data *2

★1: Data for each frame are stored sequentially, starting from address 1.
★2: Whenever the preset averaging count is reached and averaging processing terminates, the result is stored in the next available address, starting from address 1.
★3: The result of each averaging processing run is stored sequentially, starting from address 1.

∗ 4: If the averaging count is between 2 and 2000, the result is stored when the preset count is reached, starting from address 1.
If the averaging count is set to infinite (N=0), the result of each averaging processing run is stored sequentially, starting from address 1.

If the stored data are time waveform data, the spectrum, amplitude probability density, or phase derived from those data can be displayed after recall.

During auto store, the following analysis parameters cannot be altered:

Frequency span	Averaging conditions	High-pass filter
Level range	Trigger conditions	Low-pass filter
Window	Input coupling type	Envelope processing
FFT zoom factor		

TRSN: Transient store
The unprocessed sampling data (time waveform data) are stored continuously in the mass memory until all addresses become full. The stored data are not influenced by the data currently shown on the display of the SA-77. Any previously stored data (including data stored with manual or auto store) are cleared and replaced by the new data.
The store capacity is 30720 sampling points. The time interval that elapses until this capacity is reached depends on the frequency span.

Frequency span	Time interval
50 kHz	240 ms
20 kHz	600 ms
10 kHz	1.2 s
5 kHz	2.4 s
2 kHz	6.0 s
1 kHz	12.0 s
500 Hz	24.0 s
200 Hz	60.0 s
100 Hz	120.0 s

When transient store was used, alterations such as zoom and window processing can be carried out, and spectrum, amplitude probability density, and phase can be displayed. The function can also serve as a simple waveform monitor.

During auto store, the following analysis parameters cannot be altered:

Frequency span	Averaging conditions	High-pass filter
Level range	Trigger conditions	Low-pass filter
Window	Input coupling type	Envelope processing
FFT zoom factor		

● Memory Clear (CLEAR)

Clears data at specified addresses which were entered by manual store.
Data entered by auto store or transient store cannot be cleared.

```
    CLEAR :     1..   1

 001 . . 0 0 1
                              Clear end address
                              Clear start address
```
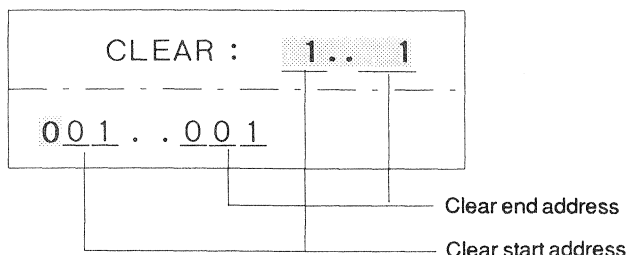
1. Enter the first address number to clear (clear start address) and the last address number to clear (clear end address) with the numeric keypad.
2. Press the |ENTER| key.
   All data contained in the specified address range are cleared.

● Step Count (STEP)

"Step" specifies the count by which the address number changes when one of the |UP| · |DOWN| [ADDRESS] keys is pressed once (for manual or auto store). It also specifies the sampling point count for transient store.

```
 STEP :  Δ        1

 0001
```
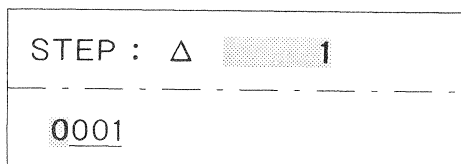
The setting range for the step count item depends on the store type, as shown below.

Store type	Step count range
Manual store	1 - 50
Auto store	
Transient store	1 - 9999

● Comment (COMMENT)

A comment of up to eight characters can be stored together with the data in the mass
memory. This comment will be displayed when the data are recalled.
During manual store, a different comment can be entered for each address, for example
to classify different sets of data. For auto store or transient store, only one comment for
all data can be entered.
Comments may also be added or altered later (☞ p. 76).
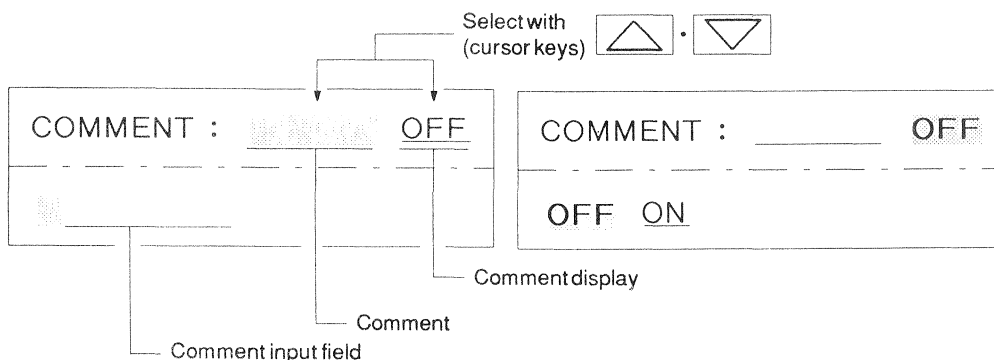
· Comment input
  To enter a comment, use the numeric keypad and the ◁·▷ (cursor keys).
  ⓪ - ⑨ (numeric keypad): Numerals 0-9
  [.] (numeric keypad):   Space
  ◁·▷ (cursor keys):   Character and symbol input

  The following three sets of characters and symbols are available with the ◁·▷
  (cursor keys). Use the [±] key to switch between them.

Set 1 (numbers and symbols)	0123456789: ;<=>? ! "#$%&' ()*+,–./
Set 2 (upper case letters)	ABCDEFGHIJKLMNOPQRSTUVWXYZ
Set 3 (lower case letters)	abcdefghijklmnopqrstuvwxyz

  The following example shows how to input the comment string "tAVE-A01".

1. Use the ◁·▷ [MARKER] keys to move the parameter cursor to the leftmost posi-
   tion and then press the ◁·▷ (cursor keys). One of the characters and symbols
   in sets 1-3 is shown at the parameter position.

2. If the displayed character is not from set 3, press the $\boxed{\pm}$ key (numeric keypad) to change to character set 3. The currently displayed character does not change at this time.
3. Press the $\boxed{\triangleleft}\cdot\boxed{\triangleright}$ (cursor keys) until "t" is displayed.
4. Use the $\boxed{\triangleright}$ [MARKER] key to move the parameter cursor one position to the right.
5. Press the $\boxed{\pm}$ key (numeric keypad) twice to switch to character set 2.
6. Press the $\boxed{\triangleleft}\cdot\boxed{\triangleright}$ (cursor keys) until "A" is displayed.
7. Use the $\boxed{\triangleright}$ [MARKER] key to move the parameter cursor one position to the right.
8. Enter "V", "E", "-", "A", "0", and "1" in the same way.
9. When the entire string is displayed, press the $\boxed{\text{ENTER}}$ key. The comment is now set.

• Displaying a comment
  Set the COMMENT item.

  ON: Comment is displayed in analysis or recall mode.
  OFF: Comment is not displayed.

■ Restrictions For Key Operation and Altering Parameter Settings

● Restrictions For Changing Menu Items
When the unit is in one of the modes shown below, certain analysis parameter items cannot be changed.
• When the analysis parameter setting mode was entered from the recall mode.
• During auto store or transient store.
• In the pause condition.

○ : Alteration possible   × : Alteration not possible   Δ : Alteration restricted under certain conditions

Menu item	Parameter setting mode from recall mode	During store operation	During pause
Menu 1			
Sampling signal and frequency span	×	×	×
Level range	×	×	×
Level unit	○	○	○
Engineering unit (EU) value	○	○	○
Engineering units ON/OFF	○	○	○
High-pass/low-pass filter	×	×	×
Input coupling type	×	×	×
Envelope processing	×	×	×
FFT zoom factor	Δ*1	×	×
Window	Δ*2	Δ*3	Δ*3
Menu 2			
Averaging conditions	×	×	×
Trigger conditions	×	×	×
Menu 3			
All items of menu 3	○	○	○
Menu 4			
Analysis parameter store	○	○	○
Analysis parameter recall	○	×	○
Store type	×	×	○
Memory clear	×	×	○
Step count	○	×	○
Comment input	○	○	○
Comment display	○	○	○

★1: Alteration not possible when recalling data stored with manual or auto store.
★2: Alteration not possible when recalling averaged spectrum data.
★3: Alteration not possible when averaging is set for spectrum domain.

● Restrictions For Key Operation

When the unit is in one of the modes shown below, certain panel keys are restricted in their operation.

- When the analysis parameter setting mode was entered from the recall mode.
- During auto store or transient store.
- In the pause condition.

○ : Operation possible   × : Operation not possible   △ : Operation restricted under certain conditions

Key	Parameter setting mode from recall mode	During store operation	During pause
[START]	×	×	○
[STOR]	△*1	○	○
[UP]・[DOWN] [ADDRESS]	○	×	○
[RCL]	×	×	○
[PRINT]	○	×	○
[PSE/CONT]	×	△*2	○
[AVE]	×	○	○
[ZOON]	△*3	×	×
[WNDW]	△*4	△*5	△*5
[◁]・[▷] [MARKER]	○	○	○
[SPEC]	△*6	○	○
[TIME]	△*6	○	○
[PDF]	△*6	○	○
[PHASE]	△*6	○	○

*1: Display conditions only are stored.
*2: Cannot be operated during transient store.
*3: Cannot be operated when recalling data stored with manual or auto store.
*4: Cannot be operated when recalling averaged spectrum data.
*5: Cannot be operated when averaging is set for spectrum domain.
*6: Cannot be operated when stored data are averaged spectrum or amplitude probability density data.

○ : Operation possible　×　: Operation not possible　△ : Operation restricted under certain conditions

Key	Parameter setting mode from recall mode	During store operation	During pause
◄► · ►◄ [X-SCALE]	○	○	○
▲▼ · ▼ [Y-SCALE]	○	○	○
UP · DOWN [FREQ SPAN]	×	×	×
UP · DOWN [LEVEL RANGE]	×	×	×
HOME	○	○	○
MENU	○	○	○
EXIT	○	○	○
◁ · ▷ · △ · ▽ [cursor keys]	○	○	○
ENTER	△*7	△*7	△*7

*7: Restrictions apply for changing parameters in analysis parameter setting mode.

STORING DATA

■ Manual Store

This procedure stores one frame of data in a specified address. The type of stored data depends on what kind of data are being displayed.

Displayed data		Stored data
Instantaneous data	Spectrum	Instantaneous time waveform data
	Time waveform	
	PDF	
	Phase	
Averaged data	Spectrum	Averaged spectrum data (arithmetic averaging/exponential averaging/peak)
	Time waveform *	Arithmetic averaged time waveform data
	PDF	Arithmetic averaged amplitude probability density data

∗ : Including display of spectrum, amplitude probability density, or phase derived from averaged time waveform data.

If the specified address already contains manually stored data, the old data in that address are cleared and replaced by the new data. Data in other addresses will not be affected. If the address contains data stored by auto store or transient store, all data (also in other addresses) are cleared, and then the data are stored in the specified address.

If the stored data are time waveform data, the spectrum, amplitude probability density, or phase derived from those data can be displayed after recall.

● Data Format

For manual store, the data and the analysis conditions selected at the time of the store process form one set of data (one data file) which is stored in one address. The format is as follows.

Mass memory capacity: 4094 blocks

Data file		
Analysis conditions and data	Analysis conditions and data	
Address 1	Address 2	· · · · · ·
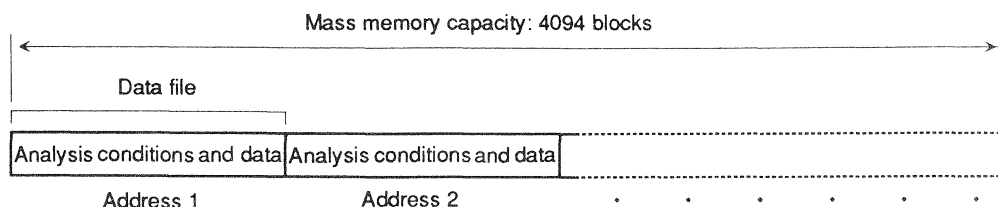
The capacity of the mass memory is 4094 blocks (1 block = 16 bytes). As the size of the data file depends on the data type and the FFT zoom factor, the number of data files which can be stored varies. The absolute maximum for the number of data files which can be managed by the unit is 150.

The file size (in blocks) and the maximum number of data files for the various data types and FFT zoom factor settings are shown in the table below. In manual store, different data types can be mixed, but the absolute maximum of 4094 blocks or 150 data files cannot be exceeded.

Data type	FFT zoom factor	Data file size (in blocks)	Maximum number of data files
Instantaneous time waveform data Averaged time waveform data	1	38	107
	2	70	58
	4	134	30
	8	262	15
Averaged spectrum data (arithmetic averaging/exponential averaging/peak)	1	31	132
	2	56	73
	4	106	38
	8	206	19
Averaged amplitude probability density data	1	14	150
	2	14	150
	4	14	150
	8	14	150

● Procedure

1. Set the STORE_TYPE on menu 4 to "MANU". When wishing to add a comment to the data, activate the comment setting and enter the comment.

2. Set averaging conditions from menu 2 if averaged data are to be stored.

3. Press the | EXIT | key to set the unit to the analysis mode.

4. Use the | UP | • | DOWN | [ADDRESS] keys to select the address in which the data are to be stored.

Address number

```
┌─────────────────────────┐
│ ┌─────────┬───────────┐ │
│ │ 0005    │ TIME      │ │
│ │         │ PSE       │ │
│ │     ∧   │ MANU      │ │
│ │  ∧ ∧★∧  │ log       │ │
│ │ ∧ │ │ ∧ │ y    1    │ │
│ │─┼─┼─┼─┼─│ x    4    │ │
│ │ │ │ │ │ │ *1        │ │
│ │ │ │ │ ∨ │ RECT      │ │
│ │ ∨ ∨ ∨   │ FREE      │ │
│ │         │ INST      │ │
│ │         │    10K    │ │
│ │         │ 0. 44     │ │
│ ├─────────┴───────────┤ │
│ │ 3.477ms   2.467ᴇ⁻⁰¹ v│ │
│ └─────────────────────┘ │
└─────────────────────────┘
```
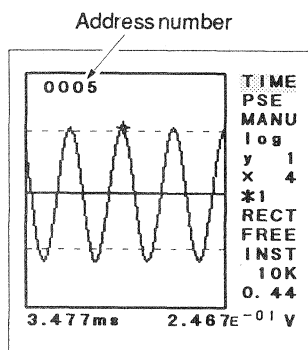
5. When the desired data (instantaneous or averaged data) are displayed, press the | STOR | key. (This is possible also in the pause mode.)
A short beep confirms that the data have been stored in the selected address. The address number shown on screen is automatically incremented by one count. When wishing to store further data, just press the | STOR | key again.

■ Auto Store

This procedure stores data continuously starting from address 1 until the mass memory becomes full. Any previously stored data (including data stored with manual or transient store) are cleared and replaced by the new data. The type of stored data depends only on the averaging conditions, not on which data are being displayed.

Averaging domain	Averaging mode	Stored data
———————	No averaging	Instantaneous time waveform data *1
Spectrum	Arithmetic averaging	Arithmetic averaged spectrum data *2
	Exponential averaging	Exponential averaged spectrum data *3
	Peak hold	Spectrum peak data *4
Time waveform	Arithmetic averaging	Arithmetic averaged time waveform data *2
PDF	Arithmetic averaging	Arithmetic averaged amplitude probability density data *2

★1: Data for each frame are stored sequentially, starting from address 1.

★2: Whenever the preset averaging count is reached and averaging processing terminates, the result is stored in the next available address, starting from address 1.

★3: The result of each averaging processing run is stored sequentially, starting from address 1.

★4: If the averaging count is between 2 and 2000, the result is stored when the preset count is reached, starting from address 1.
    If the averaging count is set to infinite (N=0), the result of each averaging processing run is stored sequentially, starting from address 1.

If the stored data are time waveform data, the spectrum, amplitude probability density, or phase derived from those data can be displayed after recall.

● Data Format

For auto store, the analysis conditions and the data are stored in the format shown below.
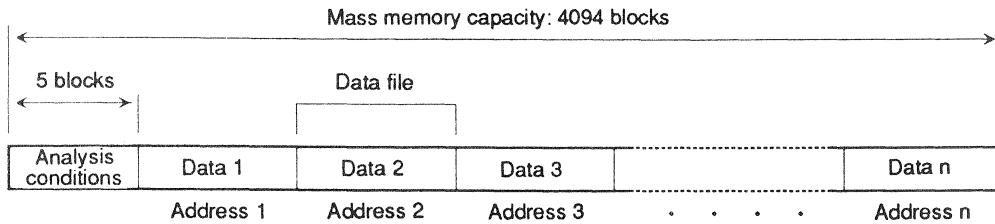
The capacity of the mass memory is 4094 blocks (1 block = 16 bytes). For storage of the analysis conditions, 5 blocks are used, therefore 4089 blocks are available for data. As the size of a data file depends on the data type and the FFT zoom factor, the number of data files which can be stored varies. The absolute maximum for the number of data files which can be managed by the unit is 150.

The file size (in blocks) and the maximum number of data files for the various data types and FFT zoom factor settings are shown in the table below.

Data type	FFT zoom factor	Data file size (in blocks)	Maximum number of data files
Instantaneous time waveform data Averaged time waveform data	1	33	123
	2	65	62
	4	129	31
	8	257	15
Averaged spectrum data (arithmetic averaging/exponential averaging/peak)	1	26	150
	2	51	80
	4	101	40
	8	201	20
Averaged amplitude probability density data	1	9	150
	2	9	150
	4	9	150
	8	9	150

● Procedure

1. Set the STORE_TYPE on menu 4 to "AUTO". When wishing to add a comment to the data, activate the comment setting and enter the comment.

2. Set averaging conditions from menu 2 to determine the data to be stored.

3. Press the $\boxed{\text{EXIT}}$ key to set the unit to the analysis mode.

4. Press the $\boxed{\text{STOR}}$ key. If averaging conditions are set, averaging begins immediately. Auto store continues until the mass memory is full or the maximum number of 150 data files is reached. During the auto store operation, the indication "AUTO" appears in reverse at the right of the screen.

Currently used address number is shown.
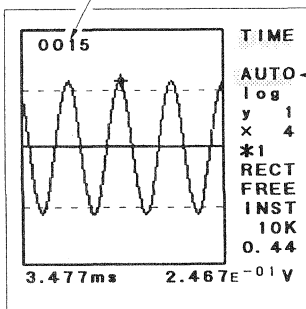
```
         TIME
 0015
         AUTO ◄──────── Reverse indication shows that auto store is in progress.
         log
         y    1
         ×    4
         *1
         RECT
         FREE
         INST
          10K
         0.44
 3.477ms    2.467E⁻⁰¹ V
```

• To temporarily interrupt auto store, press the $\boxed{\text{PSE/CONT}}$ key. To resume the operation, press the $\boxed{\text{PSE/CONT}}$ key again.

• To terminate auto store, press the $\boxed{\text{STOR}}$ key again. The data stored up to that point are retained.

• By using the repeated trigger, averaging, and auto store functions together, signals with cyclic occurrence can be averaged and the results can be automatically stored in memory.

• During auto store, the following analysis parameters cannot be altered:

Frequency span	Averaging conditions	High-pass filter
Level range	Trigger conditions	Low-pass filter
Window	Input coupling type	Envelope processing
FFT zoom factor		

■ Transient Store

This procedure stores the unprocessed sampling data (time waveform data) continuously in the mass memory. The stored data are not influenced by the currently displayed data or by the averaging setting. Any previously stored data (including data stored with manual or auto store) are cleared and replaced by the new data.

● Data Format

As opposed to the frame-based manual and auto store operations, the transient store operation continuously records the time waveform data at the 30720 sampling points. The result of input signal sampling is directly stored in the mass memory.

Analysis conditions	Time waveform data (30720 continuous sampling points)

When transient store is used, alterations such as zoom and window processing can be carried out, and spectrum, amplitude probability density, and phase can be displayed. The function can also serve as a simple waveform monitor.

As the amount of stored data is fixed, the time required for storing depends on the frequency span.

$$\text{Time required for store operation} = 30720 \times \frac{1}{\text{Frequency span} \times 2.56}$$

Frequency span	Sampling frequency	Time required for store operation
50 kHz	128 kHz	240 ms
20 kHz	51.2 kHz	600 ms
10 kHz	25.6 kHz	1.2 s
5 kHz	12.8 kHz	2.4 s
2 kHz	5.12 kHz	6.0 s
1 kHz	2.56 kHz	12.0 s
500 Hz	1.28 kHz	24.0 s
200 Hz	512 Hz	60.0 s
100 Hz	256 Hz	120.0 s

● Procedure

1. Set the STORE_TYPE on menu 4 to "TRSN". When wishing to add a comment to the data, activate the comment setting and enter the comment.

2. Press the ⟦EXIT⟧ key to set the unit to the analysis mode.

3. Press the ⟦STOR⟧ key.
   Time waveform data for 30720 sampling points are stored. During the transient store operation, the indication "TRSN" appears in reverse at the right of the screen.
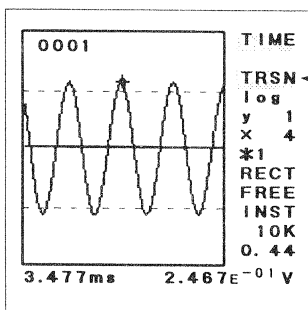
Reverse indication shows that transient store is in progress.

- If averaging is selected, averaging processing starts together with the store operation. Even if processing is not yet completed, averaging ends when the store operation ends. The averaging has no effect on the stored data.

- Temporarily interrupting the transient store function with the ⟦PSE/CONT⟧ key is not possible.

- To terminate transient store, press the ⟦STOR⟧ key again. The data stored up to that point are retained.

- When the repeated or single trigger is used, pressing the ⟦STOR⟧ key sets the unit to the standby mode. The store operation starts when the trigger is activated. After the store function has started, the trigger is disabled and restored after storing is completed.
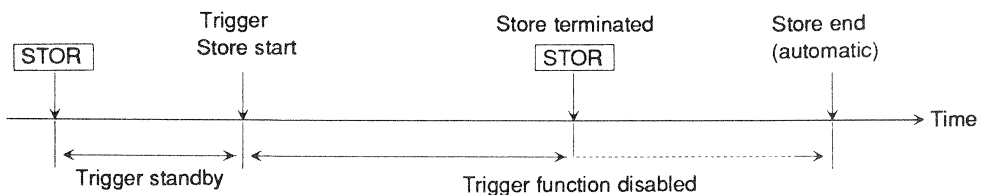
- During transient store, the following analysis parameters cannot be altered:

Frequency span	Averaging conditions	High-pass filter
Level range	Trigger conditions	Low-pass filter
Window	Input coupling type	Envelope processing
FFT zoom factor		

RECALLING DATA

Pressing the RCL key sets the unit to the recall mode and displays data stored in the mass memory. If no data are stored, the indication "NO DATA" appears.
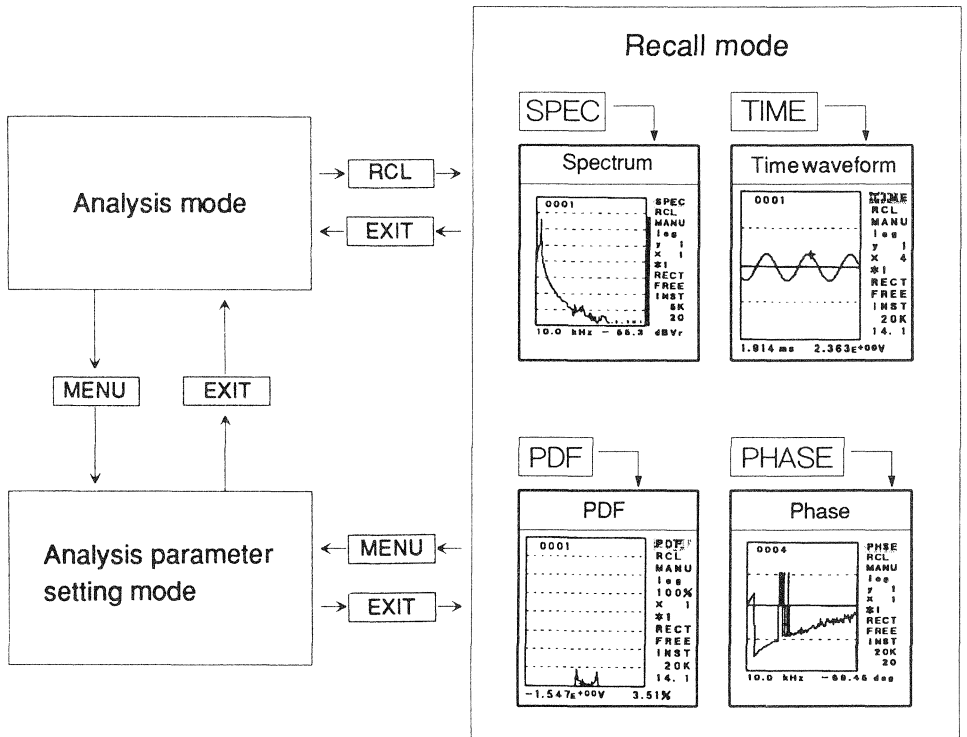
The indication "RCL" on the screen shows that the unit is in the recall mode. Other display functions for data and parameter are the same as for the analysis mode.

Data are displayed with the same analysis conditions that were set when the data were stored. Various parameters such as X axis and Y axis units, enlargement factor, etc. can be changed (☞ p. 75).
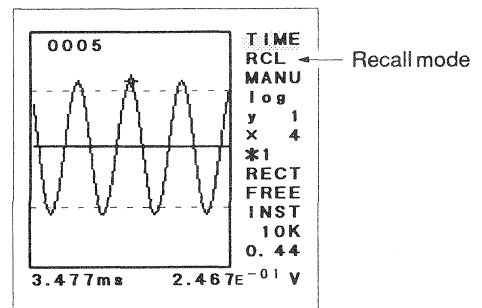
Recall mode display

■ Selecting Data for Display

● Data Stored With Manual or Auto Store

The number at the top left of the screen shows the current address number. This number can be changed with the $\boxed{\text{UP}}$ • $\boxed{\text{DOWN}}$ [ADDRESS] keys. Each push of a key changes the address number by the increment set in the step count item of menu 4 (☞ p. 57).

When recalling time waveform data (instantaneous or averaged), the spectrum, amplitude probability density, or phase derived from these data can also be displayed. When recalling averaged spectrum or amplitude probability density data, viewing in other forms is not possible.

Address number

```
          0005              TIME
                            RCL
                            MANU
                            log
                            y   1
                            x   4
                            *1
                            RECT
                            FREE
                            INST
                            10K
                            0.44
      3.477ms    2.467E-01 V
```
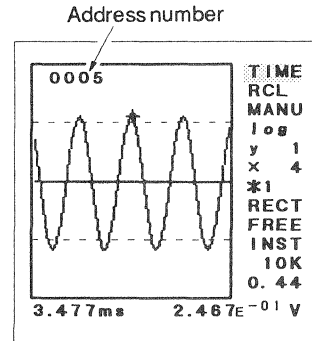
Stored data	Recall mode display				
TIME Time waveform (instantaneous data)	**TIME** Time waveform (instantaneous data)	**SPEC** Spectrum (instantaneous data)	**PDF** PDF (instantaneous data)	**PSHE** Phase (instantaneous data)	
T̄ĪM̄Ē Time waveform (averaged data)	**T̄ĪM̄Ē** Time waveform (averaged data)	**S̄P̄ĒC̄** Spectrum	**P̄D̄F̄** PDF	**P̄H̄S̄Ē** Phase	
S̄P̄ĒC̄ Spectrum (averaged data)	**S̄P̄ĒC̄** Spectrum (averaged data)				
P̄D̄F̄ PDF (averaged data)	**P̄D̄F̄** PDF (averaged data)				

Data types are distinguished by the line above the letters in the reverse display at the top right of the screen.

No line: Instantaneous data
Straight line: Averaged data
Broken line: Data derived from averaged time waveform data

● Data Stored With Transient Store

Position of leftmost screen data

A part of the data for the 30720 sampling points
is shown. The number at the top left of the screen
shows the sampling point count for the data at the
left edge of the screen, calculated from the start
of stored data. This number can be changed with
the UP • DOWN [ADDRESS] keys. Each push
of a key changes the number by the increment set
in the step count item of menu 4 (☞ p. 57).

```
┌──────────────────┬──────┐
│  01251           │ TIME │
│                  │ RCL  │
│                  │ MANU │
│                  │ log  │
│                  │ y   1│
│                  │ x   4│
│                  │ *1   │
│                  │ RECT │
│                  │ FREE │
│                  │ INST │
│                  │  10K │
│                  │ 0.44 │
│ 3.477ms  2.467E⁻⁰¹ V    │
└──────────────────┴──────┘
```

┌ Store start point
                                              Stored instantaneous data

┌─────────┐
│ 01251 │
└─────────┘

◄── 1251 sampling points ──►

Displayed data

As time waveform data are stored, the spectrum, amplitude probability density, or phase
derived from these data can be displayed. It is also possible to change the FFT zoom fac-
tor. When such changes are made, they take effect from the data displayed at the left
edge of the screen. The number of affected data depends on the FFT zoom factor.

FFT zoom factor	Number of data processed
1	256 sampling points
2	512 sampling points
4	1024 sampling points
8	2048 sampling points

The X axis marker value when displaying time waveform data shows the time from the
display start point (not the store start point) to the marker position.

■ Changing Display Parameters

Recalled data are initially displayed with the same analysis conditions as used during store. With the operation keys and the menus, the settings can be changed to view the data in a different format.

Display parameter	Operation key or menu
Displayed data *1	$\boxed{\text{SPEC}}$, $\boxed{\text{TIME}}$, $\boxed{\text{PDF}}$, $\boxed{\text{PHASE}}$
Marker position	$\boxed{\triangleleft}$·$\boxed{\triangleright}$ [MARKER]
X axis enlargement factor *2	$\boxed{\leftrightarrow}$·$\boxed{\blacktriangleright\blacktriangleleft}$ [X-SCALE]
X axis display area shift *2	$\boxed{\triangleleft}$·$\boxed{\triangleright}$ (Cursor keys), $\boxed{\text{HOME}}$
Y axis enlargement factor	$\boxed{\updownarrow}$·$\boxed{\mathtt{I}}$ [Y-SCALE]
Y axis display area shift	$\boxed{\triangle}$·$\boxed{\triangledown}$ (Cursor keys), $\boxed{\text{HOME}}$
Window *3	$\boxed{\text{WNDW}}$
FFT zoom factor *4	$\boxed{\text{ZOOM}}$
Engineering unit function (ON/OFF)	Menu 1
Frequency unit	Menu 3
Spectrum differentiation and integration	Menu 3
Harmonic line display (ON/OFF)	Menu 3
Harmonic line base frequency	$\boxed{\triangleleft}$·$\boxed{\triangleright}$ [MARKER], $\boxed{\text{ENTER}}$
Level scale (logarithmic/linear)	Menu 3
Grid display (ON/OFF)	Menu 3
Marker display (ON/OFF)	Menu 3
Comment input and display (ON/OFF)	Menu 4

* 1: Cannot be changed when recalling averaged spectrum data or averaged amplitude probability density data.
* 2: Limited by the stored FFT zoom factor.
* 3: Cannot be changed when recalling averaged spectrum data.
* 4: Can only be changed when recalling time waveform data stored with transient store.

● Procedure

When data were stored with auto store or transient store, all data are displayed with the new (changed) conditions. For data stored with manual store, analysis conditions are stored along with the data in each address. A change in conditions therefore affects only the currently recalled data from one address.

• To change an operation key setting, just press the respective key.

• To change a menu setting, proceed as follows.
   1. Press the MENU key to set the unit to the analysis parameter setting mode.
   2. Change the desired parameter.
   3. Press the EXIT key to return to the recall mode.
      The data are now displayed with the new setting.

● Changing Display Parameters Stored in Memory

Analysis conditions are stored in the mass memory along with data. These conditions can be changed and then stored again, so that the new conditions are active the next time the recall mode is used.

1. When recalling data stored with manual store, select the address whose stored parameters you want to change. For data stored with auto store or transient store, any data can be displayed.

2. Change the parameters to the new settings. When finished, press the EXIT key to return to the recall mode.

3. Press the STOR button.
   A short beep confirms that the new settings have been stored.

SPECIFICATIONS

● Input section

Number of channels	1
Input impedance	100 kΩ ±10%, unbalanced
Input coupling type	AC or DC (for 0.0316 Vrms range or higher)
Frequency range	AC coupling: 0.5 Hz to 50 kHz DC coupling: DC to 50 kHz

Input connector
7P connector

A: Preamplifier power supply (+12 V ±10 %, 2 mA)
B: Ground
C: Signal
D: Preamplifier power supply (−12 V ±10 %, 2 mA)
E: Ground
F: Ground
G: Ground

Suitable connector type: TC1108-12A10-7M
(TAJIMI ELECTRONICS CO., LTD.)

Level range	−50 to +20 dB (0.00316 to 10.0 Vrms), in 10-dB steps
Input filter	3rd-order Butterworth filter (switchable) High-pass filter: 5, 50, 1000 Hz (−10% point) Low-pass filter: 1, 5, 10 kHz (−10% point) Filter slope: −18 dB/oct.
Overload indication	"OVER" appears when input waveform peak exceeds the selected level range.
Detector	Absolute value detector for envelope processing

● Trigger section

Trigger source	Internal (input signal) or external trigger signal
Trigger mode	Free-run, repeat, single
Added functions	Pre-trigger, post-trigger
Trigger slope setting	Rising edge (+) or falling edge (−)
Trigger level	−7/8 to +7/8 of level range, in 1/8-steps

● Analyzer section

Analysis functions	Spectrum, time waveform, amplitude probability density, phase
Frequency range	100, 200, 500 Hz, 1, 2, 5, 10, 20, 50 kHz
Anti-aliasing filter	7th-order Chebyshev filter Cutoff frequency: 100, 200, 500 Hz, 1, 2, 5, 10, 20, 50 kHz Attenuation: 95 dB/oct. or better
A/D conversion	12 bit
Dynamic range	72 dB
Window types	Rectangular, hanning, flat-top
Number of display lines	101
FFT zoom factor	1, 2, 4, 8 Calculation for 256 points (101 lines), 512 points (201 lines), 1024 points (401 lines), 2048 points (801 lines), with 101 lines being displayed at any one time, and display area shift used to view zoomed data.
Averaging processing	Processing domain: spectrum, time waveform, amplitude probability density Processing modes: arithmetic averaging, exponential averaging, peak hold Number of averaging runs: 2 to 8000
Secondary processing	FFT on time waveform data stored in memory

● Display section

Display type	128 x 128 dot LCD (55 x 55 mm)
Display contents	Data (spectrum, time waveform, amplitude probability density, phase), analysis parameter, menus (for analysis parameter setting), marker value (X axis, Y axis), grid, harmonic lines, processing value for spectrum (integral, double integral, differential, two-step differential)
X axis units	Spectrum: Hz, KCPM, ORD Time waveform: μs, ms Amplitude probability density: V, EU Phase: Hz, KCPM, ORD

● Y axis units   Spectrum: V, Vr, dBV, dBVr, EU, EUr, dBEU, dBEr
                   Time waveform: V, EU
                    Amplitude probability density: %
                   Phase: degrees
                   (EU value can be set in N.NN x 10^N or NNN.N dB.)

● Memory section

  Memory medium   Static RAM (with lithium backup battery)

  Data preservation   Approx. 2 years

  Storable items   Measurement data, analysis conditions

  Store functions   Manual (individual address), auto store (continuous),
                       transient store of time waveform data

  Memory capacity   Manual store (number of data files)

		FFT zoom factor			
		1	2	4	8
Data	TIME	107	58	30	15
	$\overline{\text{TIME}}$	107	58	30	15
	$\overline{\text{SPEC}}$	132	73	38	19
	$\overline{\text{PDF}}$	150	150	150	150

TIME : Instantaneous time waveform data
$\overline{\text{TIME}}$: Averaged time waveform data
$\overline{\text{SPEC}}$: Averaged spectrum data
$\overline{\text{PDF}}$: Averaged amplitude probability density data

Auto store (number of data files)

		FFT zoom factor			
		1	2	4	8
Data	TIME	123	62	31	15
	$\overline{\text{TIME}}$	123	62	31	15
	$\overline{\text{SPEC}}$	150	80	40	20
	$\overline{\text{PDF}}$	150	150	150	150

Transient store: Time waveform data for 30720 sampling
                 points

● External control section

I/O connector   For connection of printer CP-10 or use as RS-232-C interface

Connector type: D05-20-SA-1L1 (Japan Aviation Electronics Industry, Limited)

I/O
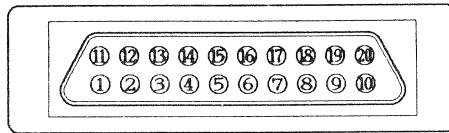
Pin number	Signal designation	Application
19	GND	Printer interface
4	D0	
14	D1	
3	D2	
13	D3	
2	D4	
12	D5	
1	D6	
11	D7	
7	STROBE	
15	ACK	
16	BUSY	
17	PE	
18	SELECT	
5	AUTO LF	
6	RESET	
8	GND	
20	TXD	RS-232-C interface
10	RXD	
19	GND	
9	GND	

Suitable connector type: D05-20H-R (Japan Aviation Electronics Industry, Limited)

Printer interface   Dedicated parallel I/O connection for printer CP-10.

Connection cable (optional): CC-81

RS-232-C interface   Flow control: yes
    Transmission configuration:
         half-duplex
    Data word length: 8 bit
    Start bit: 1
    Stop bit: 2
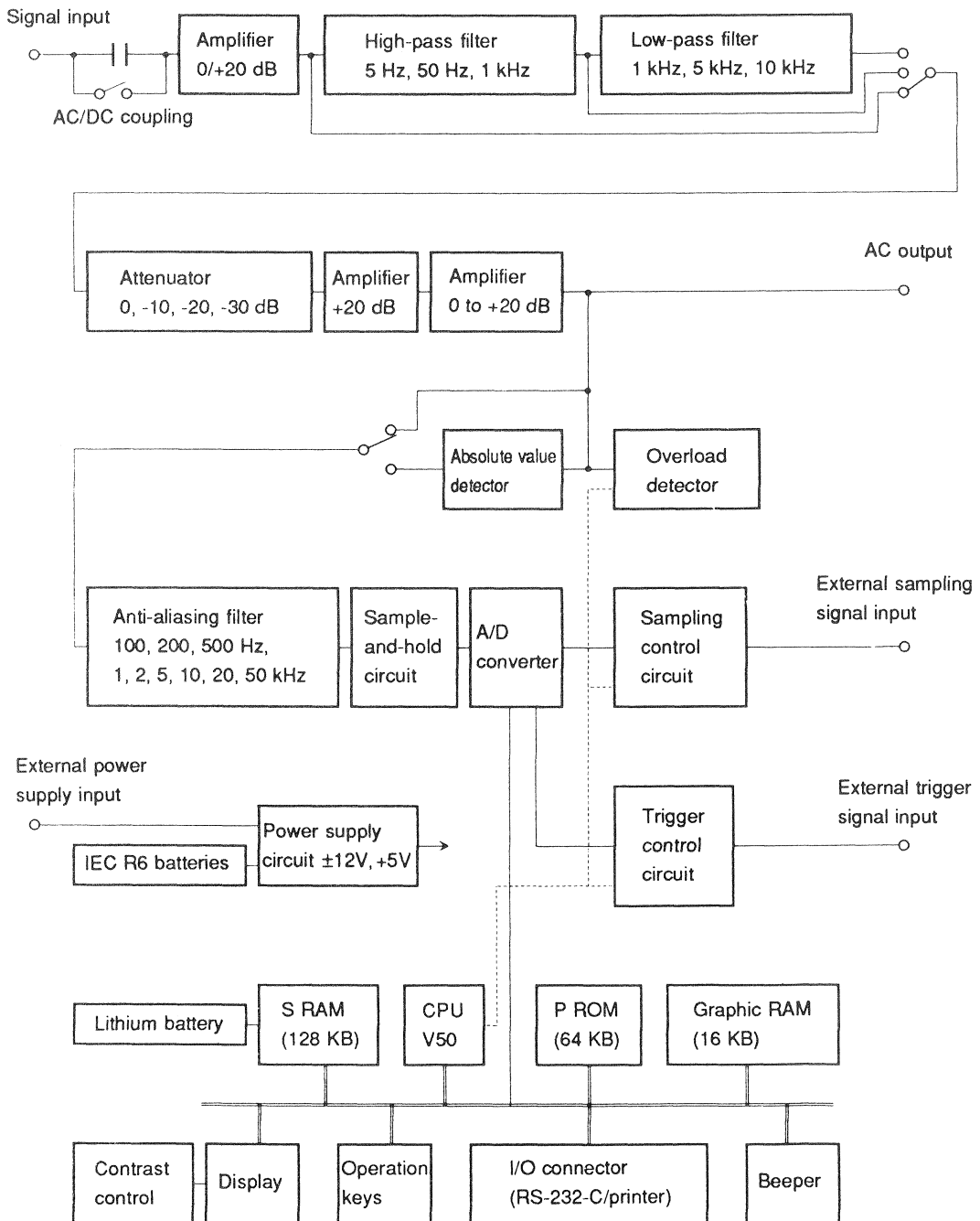   Parity check: none
    Baud rate: 1200, 2400, 4800, 9600 bps
    Connection cable (optional):
         CC-80 (wiring chart see p.84)

External trigger signal input
    TTL level input
    Connector type: HSJ1045-01-010
         (Hosiden Electronics Co., LTD.)
    Suitable plug type: AV-25, cap MC-08 (Rion)

External sampling signal input
    TTL level input
    Connector type: HSJ1045-01-010
         (Hosiden Electronics Co., LTD.)
    Suitable plug type: AV-25, cap MC-08 (Rion)

AC output   Output voltage: 3.54 Vrms (full-scale)
    Connector type: HSJ1045-01-010
         (Hosiden Electronics Co., LTD.)
    Suitable plug type: AV-25, cap MC-08 (Rion)

● Power supply section

Power supply   IEC R6 battery x 8

Battery life   Approx. 3.5 hours (manganese batteries, at 20°C, continuous use)
    Approx. 9.0 hours (alkaline batteries, at 20°C, continuous use)

Memory backup battery Lithium battery CR-1/3N

External power supply 8 to 15 V DC (from AC adapter NC-10 or NC-11)

Power consumption   Approx. 1.7 W

● Ambient conditions 0 to 50°C (operation guaranteed)
  for operation   5 to 40°C (specifications guaranteed)
    Max. 90% relative humidity (40°C)

● Dimensions   Approx. 21 (H) x 11 (W) x 4 (D) cm

● Weight   Approx. 650 g (including batteries)

● Supplied accessories

IEC R6 battery	8
Lithium battery CR-1/3N	1
External input adapter (UA-01)	1
External output cable (CC-24)	1
Plug (AV-25)	1
Cap (MC-08)	1
Carrying strap	1
Case	1
Instruction manual (main unit)	1
Instruction manual (RS-232-C interface)	1

● Block diagram

Signal input

Amplifier
0/+20 dB

High-pass filter
5 Hz, 50 Hz, 1 kHz

Low-pass filter
1 kHz, 5 kHz, 10 kHz

AC/DC coupling

AC output

Attenuator
0, -10, -20, -30 dB

Amplifier
+20 dB

Amplifier
0 to +20 dB

Absolute value
detector

Overload
detector

External sampling
signal input

Anti-aliasing filter
100, 200, 500 Hz,
1, 2, 5, 10, 20, 50 kHz

Sample-
and-hold
circuit

A/D
converter

Sampling
control
circuit

External power
supply input

External trigger
signal input

Power supply
circuit ±12V, +5V

IEC R6 batteries

Trigger
control
circuit

Lithium battery

S RAM
(128 KB)

CPU
V50

P ROM
(64 KB)

Graphic RAM
(16 KB)

Contrast
control

Display

Operation
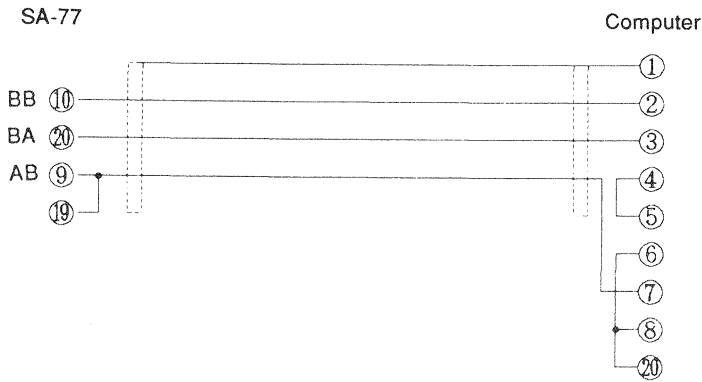keys

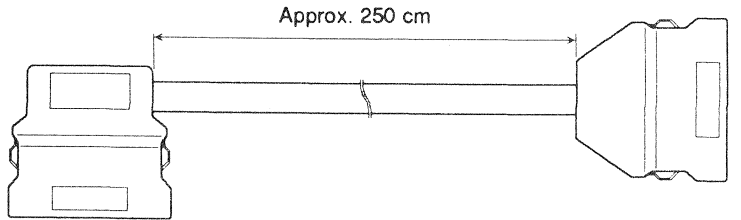I/O connector
(RS-232-C/printer)

Beeper

● Connecting cable (optional) wiring chart

CC-80 (RS-232-C interface cable)

Japan Aviation Electronics Industry, Limited
D05-20H-R / D05-20PC-F0

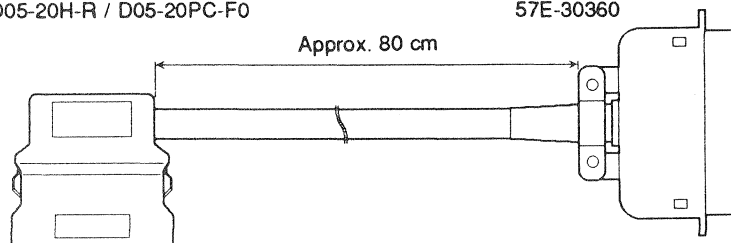Japan Aviation Electronics Industry, Limited
DB25P / DBCJ9

Approx. 250 cm

SA-77

Computer

BB ⑩
BA ⑳
AB ⑨
⑲

①
②
③
④
⑤
⑥
⑦
⑧
⑳

BB: Received data
BA: Send data
AB: Signal ground

CC-81 (printer cable)

Japan Aviation Electronics Industry, Limited
D05-20H-R / D05-20PC-F0

DAI-ICHI DENSHI KOGYO K.K.
57E-30360

Approx. 80 cm

SA-77   Computer

SA-77		Computer
⑦	—	①
④	—	②
⑭	—	③
③	—	④
⑬	—	⑤
②	—	⑥
⑫	—	⑦
①	—	⑧
⑪	—	⑨
⑮	—	⑩
⑯	—	⑪
⑰	—	⑫
⑱	—	⑬
⑤	—	⑭
⑥	—	㉛
⑲	—	⑯
⑧	—	⑲

— 85 —