HIOKI

INSTRUCTION MANUAL

8840

FFT ANALYZER

HIOKI E.E. CORPORATION

Contents

Safety Notes

Safety symbols

This manual includes important directions for safe operation and maintenance of the 8840 unit.
Note carefully the following safety points before using the unit.

⚠	The ⚠ indication on the tester means that the user should refer to the corresponding part of the operating instructions identified by a ⚠⃞ indication before carrying out the measurement operation. The ⚠ indication in this manual indicates particularly important parts of the explanation which the user should read.
⏚	Indicates a grounding terminal.
⏛	Indicates a fuse.

The following three levels of heading are also used in this manual to prioritize warnings.

⚠ DANGER	Applies to operations which if carried out wrongly carry a very serious danger of accident to the user, including the possibility of a fatal accident.
⚠ WARNING	Applies to important notes on operation and handling accompanied by a risk of serious injury (electric shock accidents), damage to the tester, or fire risk.
CAUTION	Applies to operations which carry the risk of damage to the tester or a failure to carry out measurement correctly.
Note	Refers to advisory information about operation and handling.

⚠ DANGER

- **To avoid the danger of electric shock or damage to the unit, never apply more than 450 V (temperature unit;more than 250V), (either AC or DC), between a pair of input units or between an input unit and the frame. In particular, if a power line capable of carrying a large current is connected and applies an excess voltage, there is a danger of a short circuit accident.**

- To avoid the danger of electric shock or damage to the unit, when making a measurement of the voltage of power line capable of carrying a large current, always connect the unit to the secondary of the circuit breaker.
- If any metal parts of the input cables are exposed there is a danger of electric shock. Use only the supplied 9574 input cables.
- In order to avoid accidents from electric shock, before replacing an input unit, check that the input cables are disconnected, turn off the power, and remove the power cable.
- Normally keep all eight input units installed permanently. If any input unit is not fitted, it must be replaced by a blanking panel. If the unit is operated with an input unit not in place and not blanked off, it poses a shock hazard.
- If the DC power supply cord switch is ON and the cord is connected to a battery or other DC power supply, there may be sparks. For this reason, always make sure the switch is OFF before connection (Only the 8840-01 usable DC power supply).
- In order to avoid electric shock, before removing or fitting input units or changing the fuse, be sure to remove the input cables and the power cord.
- In order to prevent the danger of fire etc., be sure to use a new fuse of the proper current and voltage specifications as shown on the rear panel of the main unit (Only the 8840-01 usable DC power supply).

⚠ WARNING

- The logic inputs are not floating. Although four sets of logic probes can be connected, they all have a common ground with the main unit.
- To prevent damage to the 8840 unit, never exceed the limits in the table on the below for the various input connections.
- The unit should always be operated in the range of 5℃ to 40℃ and 35% to 80% relative humidity. Avoid operation in direct sunlight, in dusty conditions or in the presence of corrosive gases.

Input connection	Maximum capacity
8916 inputs 8917 inputs 8919 inputs	500V DC+AC peak
8918 inputs	100V AC/DC
EXT TRIG START STOP	-5V to +10V
TRIG OUT GO · NG	20V to +30V 500mA MAX 200mA MAX

Chapter Summary

Chapter 1 describes the outline for the FFT function.

Chapter 2 describes the analysis function of the FFT function.

Chapter 3 describes the screen displays of the FFT function.

Chapter 4 describes the basic operations of the FFT function.

Chapter 5 describes the setting items and method of the FFT function.

Chapter 6 describes the 8919 FFT analog unit.

Chapter 7 describes the saving file of the screen data.

Chapter 1
What is the FFT Function?

1.1 Outline

- This allows a Fourier transform of the sampled waveform to be calculated, giving a frequency spectrum.
- The 12 types of analyses are possible: storage waveform [STR], linear spectrum [LIN], RMS spectrum [RMS], power spectrum [PSP], auto correlation function [ACR], histogram [HIS], transfer function [TRF], cross power spectrum [CSP], cross correlation function [CCP], unit impulse response [IMP], coherence function [COH], octave correlation function [OCT].
- FFT calculation can be performed on waveform data sampled in the memory recorder function.

Specifications

■ FFT channel mode	1 CHFFT 1 channel FFT 2 CHFFT 2 channel FFT
■ Frequency range setting	133 mHz to 80 kHz (for the TIME/DIV setting of the MEM function)
■ Dynamic range	72 dB (theoretical value)
■ Number of samples	1000 points
■ Frequency resolution	1/400
■ Anti-aliasing filter	Automatic setting of cutoff frequency coupled to the frequency range. Can be turned on or off (8919 FFT analog unit only).

■ Analysis channel setting — Any channel (1 to 8 channels) can be selected for both 1CHFFT and 2CHFFT.

■ FFT analysis mode setting

STR	Storage waveform
LIN	Linear spectrum
RMS	RMS spectrum
PSP	Power spectrum
ACR	Auto-correlation function
HIS	Histogram
TRF	Transfer function
CSP	Cross-power spectrum
CCR	Cross-correlation function
IMP	Unit-impulse response
COH	Coherence function
OCT	Octave analysis

■ Display format function

Single	Split screen not used.
Dual	Screen is divided into two parts.
Nyquist	Nyquist display

■ Window function setting

Rectangular	Square-wave window function
Hanning	Hanning window function
Exponential	Exponential window function

■ X-axis setting

Time	Time axis display
Linear-Hz	Frequency display
Log-Hz	Displays the frequency spectrum using a logarithmic scale
Linear-Volt	Measurement range of the input unit (HIS only)
Linear-Nyquist	Indicates the real-number part of the data (Nyquist only)

■ Y-axis setting

Linear-Real	Indicates the real-number part of the data in voltage units.
Linear-Imag	Indicates the imaginary-number part of the data in voltage units.
Linear-Mag	Indicates the data in voltage units.
Log-Mag	Indicates the data in decibels.
Phase	Indicates the angle between the real and imaginary parts in degrees.

	Linear-Nyquist Indicates the imaginary-number part of the data (Nyquist only).
■ Averaging interval	OFF, 2 to 4096 Can be set for both the time axis and the frequency axis. Peak hold is also provided.
■ Reference data setting	NEW DATA (calculated as waveform is read) FROM MEMORY (calculation done from waveform in memory)
■ Waveform decision function	OFF, OUT, ALL-OUT (when using single or Nyquist display format).
■ Display scale setting	AUTO, MANUAL

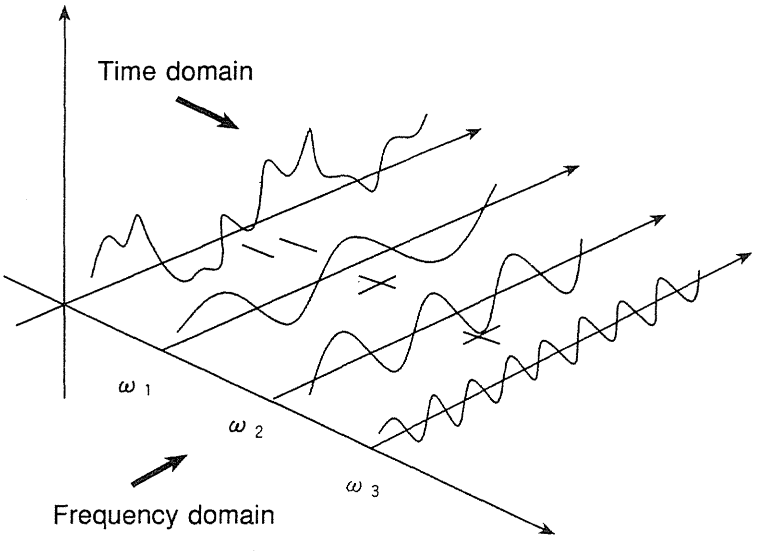
1.2 Basic Concept of Analysis Function

FFT stands for Fast Fourier Transformation, which is a calculation method used to decompose a time-domein waveform into frequency components. By performing FFT calculation, various calculations can be performed.

To perform FFT calculation using the unit, there are following two method:
1. Performs FFT calculation on the waveform data sampled in the memory function.
2. Performs FFT calculation on new sampling data in the FFT function.
   It displays operation results in graphic form on the screen or prints them out.

(1) Concept of time domain and frequency domain

The signals measured by this memory recorder have values which correspond to time, that is the signals are functions of time.
Waveform ① shown in the figure below is an example of such a signal.
Signals which are expressed as a function of time are called time domain signals.
In reality, a signal consists of a number of sine-waves of different frequencies, called frequency components, which combine to create the final shape of the waveform. Expressing waveform ① the source signal, as a function of its frequency components yields a frequency domain representation.
Often, the characteristics of a signal which cannot be easily analyzed in the time domain, can be clearly revealed by the frequency domain representation.



(2) FFT analyzer and spectrum analyzer

There are two types of measurement instruments for frequency domain analysis. One is the spectrum analyzer, and the other is the FFT analyzer. A spectrum analyzer uses a number of hardware analog filters to extract the spectrum of the signal. The FFT analyzer calculates the spectrum from a digital representation of the signal.

Each of these instruments has its own advantages and disadvantages. For example, the FFT analyzer can analyze waveforms which have a DC component, whereas the spectrum analyzer cannot. On the other hand, the spectrum analyzer can analyze the spectrum of a very high frequency signals, while the FFT analyzer cannot.

Furthermore, the spectrum analyzer only extracts the spectrum. However, the FFT analyzer calculates both the real and imaginary components of the spectrum, so that various additional calculations can be performed. For example, the FFT analyzer can calculate the energy of the spectrum (power spectrum), multiply two waveforms (cross power spectrum), obtain the frequency response of a system (transfer function), and produce a correlation diagram of one or two waveforms on the time axis.

(3) Physical meaning of Fourier transformation analysis

The following equations define the Fourier transformation and the Inverse Fourier transformation.

$$F(\omega) = \Im[f(t)] = \int_{-\infty}^{+\infty} f(t) \cdot \exp(-j\omega t)dt \tag{1.1}$$

$$f(t) = \Im^{-1}[F(\omega)] = \frac{1}{2\pi}\int_{-\infty}^{+\infty} F(\omega) \cdot \exp(j\omega t)d\omega \tag{1.2}$$

ω = $2\pi f$

j	imaginary number unit
f(t)	non-cyclic function
$\Im$	Fourier transformation
exp	natural logarithm

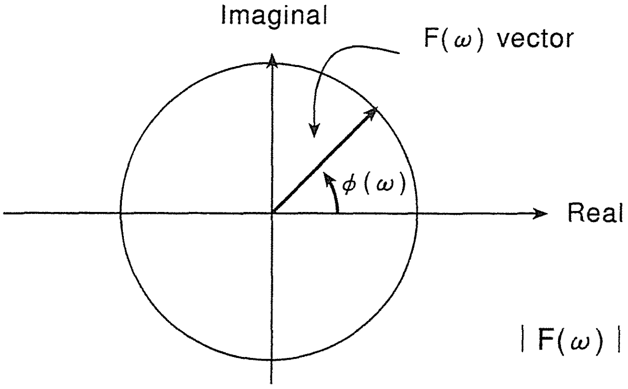
The function F (ω) generally results in a complex number, and can be expressed as follows.

$$F(\omega) = |F(\omega)| \cdot \exp(j\phi(\omega)) = |F(\omega)| \angle\phi(\omega) \tag{1.3}$$

$$\Im[f(t)] = F(\omega) = F(j\omega) \tag{1.4}$$

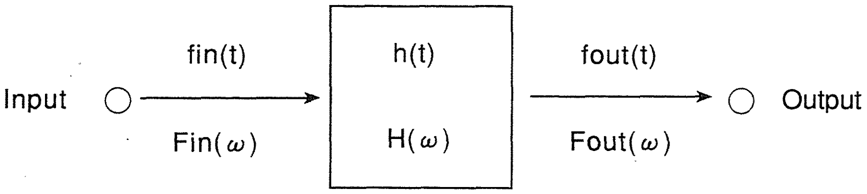
$\mid F(\omega) \mid$	Absolute-value spectrum of f(t)
$\phi(\omega)$	Unit spectrum of the phase of f(t)

When conversion is made from the time domain to the frequency domain, the magnitude information and phase information are clearly expressed as indicated in equation (1.3). The figure below shows F (ω) in vector form.



(4) Application of Fourier Transformation

The following is an example of how to obtain the stationary response of a stationary linear system using the above-mentioned Fourier Transformation method.



Stationary linear system

fin(t), fout(t), h(t) and t and τ are defined in the time domain as follows:

fin(t)	Time function of input (source signal)
fout(t)	Time function of output (response function)
h(t)	Unit impulse response of linear system
t , τ	Time

The relationship between the input and output is expressed as follows:

$$fout(t) = \int_{-\infty}^{+\infty} fin(\tau) \cdot h(t-\tau) d\tau \qquad (1.5)$$

This indicates that the response of the linear system can be determined just by knowing the unit impulse response h(t) of the system.

The following describes the relationship between the input and output in the frequency domain.
In the frequency domain, Fin(ω), Fout(ω), H(ω), and ω are defined as follows:

Fin(ω)	Fourier transformation of fin(t)
Fout(ω)	Fourier transformation of fout(t)
H(ω)	Fourier transformation of h(t)
ω	Frequency

The relationship between the input and output is expressed as follows:

$$Fout(\omega) = Fin(\omega) \cdot H(\omega) \tag{1.6}$$

Therefore, when fin(t) and fout(t) are measured, the system transfer function H (ω)and the unit impulse response h(t) can be obtained by performing an FFT operation and an inverse FFT operation.

These are the basic concepts behind the 8840 Memory HiCorder.

1.3 Aliasing Distortion

(1) A/D conversion

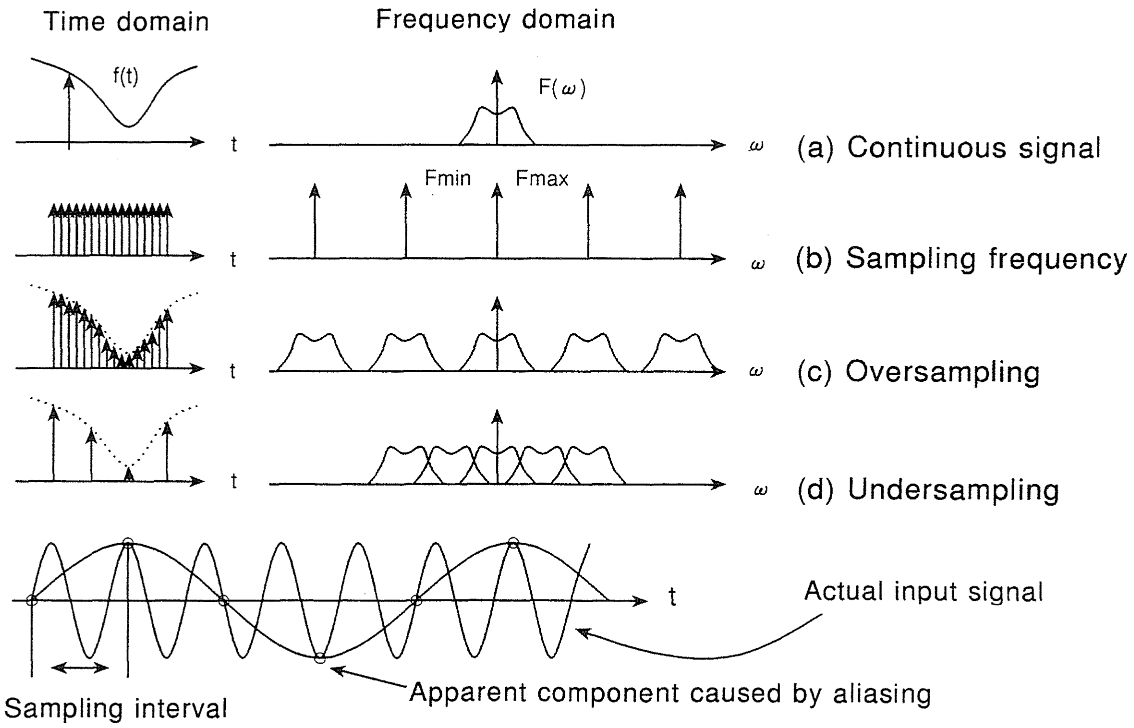
- In the 8840, the input signal is converted from analog into digital form, and all processing is performed on the digital values. This process of A/D conversion is referred to as sampling. The sampling process can be mathematically characterized as a multiplication of a continuous signal by the unit impulse string function.
- If the signal clock-in cycle, that is, the sampling interval, is grater than a certain value, erroneous information starts to appear in the digital representation of the signal.
- The phenomenon where the spectrum of an undersampled signal overlaps onto images of itself (as shown in the figure below) is referred to as frequency aliasing.
- The sampling theorem gives the lowest sampling frequency before the spectra begin to overlap.
- This sampling frequency is known as the Nyquist frequency.

$Fs = 2 \cdot Fmax$

Fmax Highest frequency in input signal

Fs Nyquist frequency

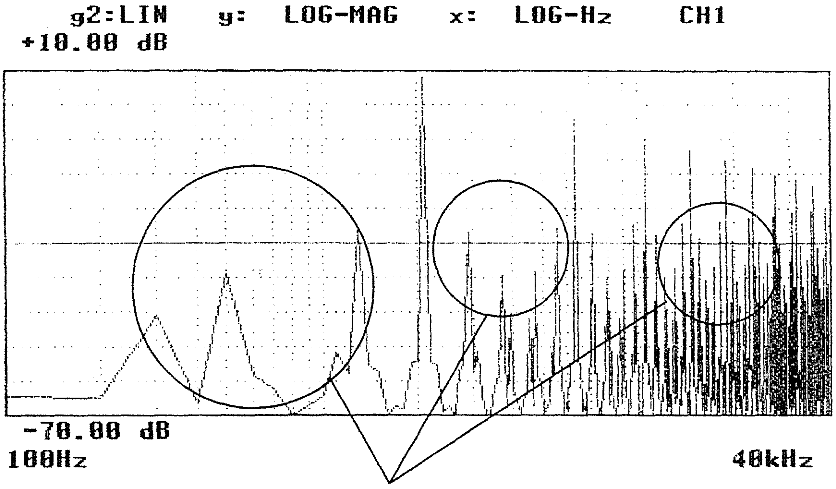
- If sampling is performed with a sampling frequency which is lower than the Nyquist frequency determined by the sampling theorem, the digital signal appears to contain frequency components which do not exist in the original signal.



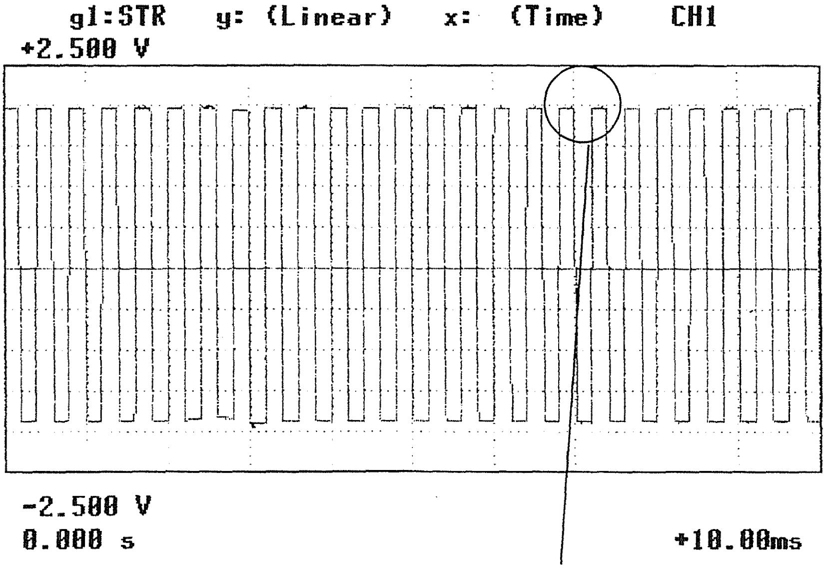
(2) Anti-aliasing filter

- If the input signal is regarded as having an unlimited bandwidth, aliasing distortion is an unavoidable consequence of sampling.
- For an FFT operation, a consequence of aliasing distortion is that a number of frequency spectra appear that do not actually exist in the original input signal.
- This problem can be solved by passing the input signal through a low-pass filter whose cut-off frequency is one-half the sampling frequency before sampling. This filter is referred to as an anti-aliasing filter.
- The 8919 FFT analog unit available for the 8840 has such an anti-aliasing filter.

● When an anti-aliasing filter is not used.

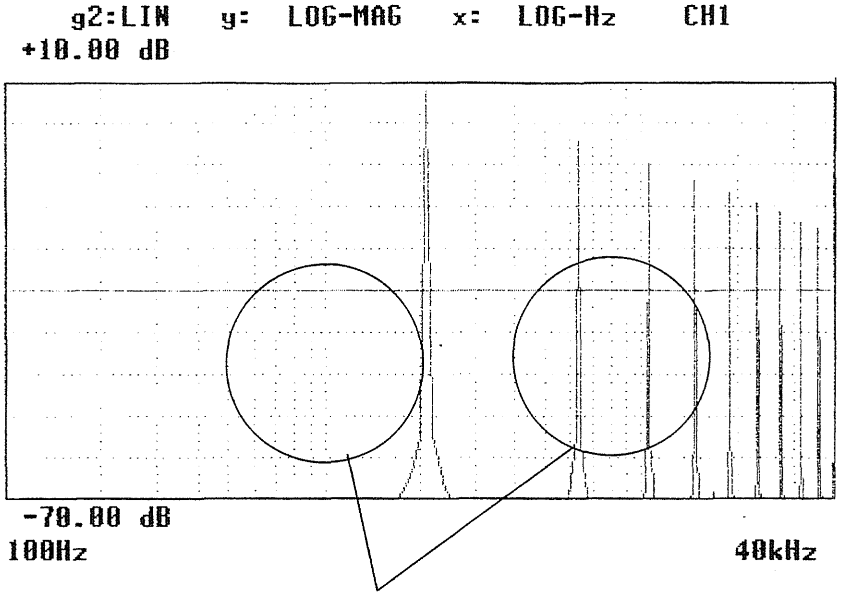


These spectra are caused by aliasing distortion of frequency components which are higher than half the sampling frequency of the A/D converter. They do not exist in the original input signal, yet they appear in the spectrum.

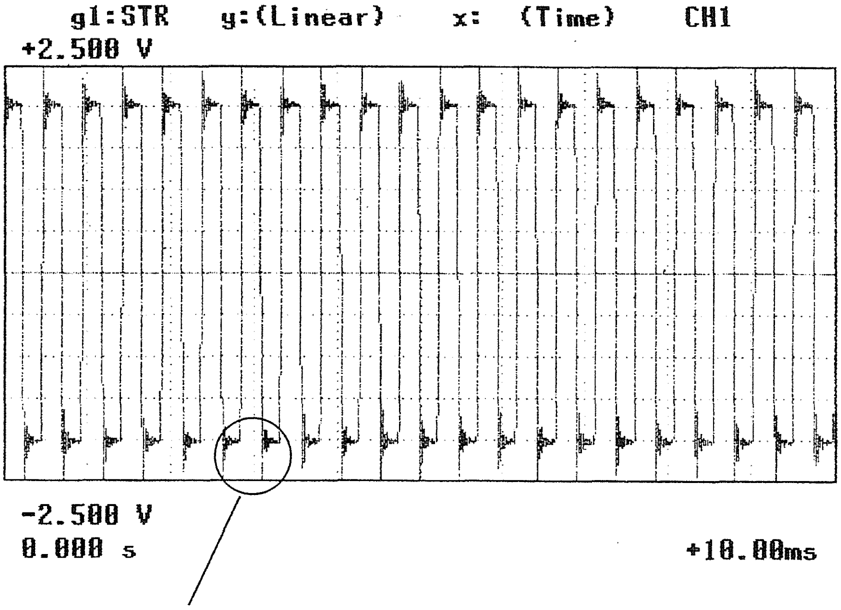


Since an anti-aliasing filter is not used for this square wave, a sharp edge is observed through a wide-band amplifier. The edge of the square-wave contains very high-frequency components.

- When an anti-aliasing filter is used



Spectra caused by aliasing distortion are clearly eliminated. The graph shows only the actual spectrum of the input signal.

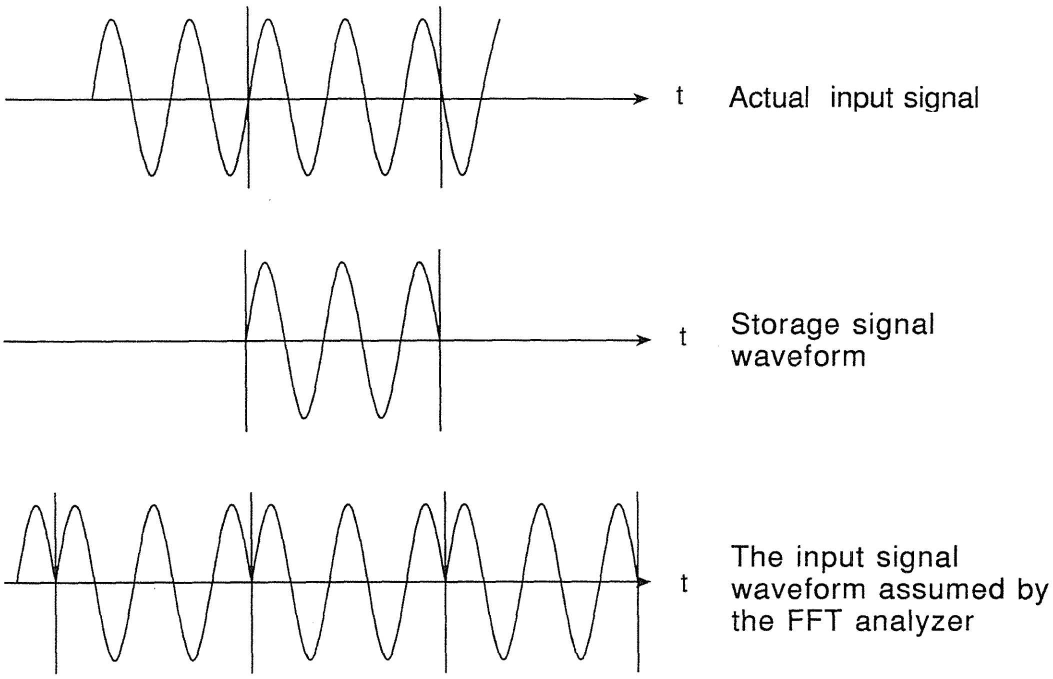


Due to the sharp cut-off characteristic of the anti-aliasing filter, the edge of the square wave contains a ripple.

1.4 Windows and Leakage

(1) Window processing

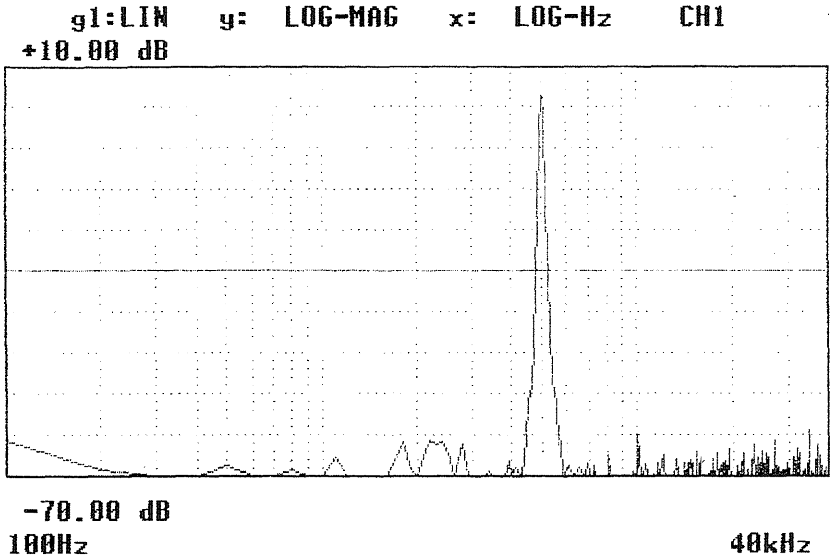
- The Fourier transformation theorem is defined as an integration between negative infinity and positive infinity. However, for actual measurements, this calculation is impossible. Therefore, only a limited portion of the continuous signal is clocked in and processed. This is called window processing.
- That is, the frequency spectrum is calculated for data within a limited time period.
- In terms of the FFT algorithm, the input signal is assumed to be a periodic function for the calculation. In other words, it is assumed that the data for this limited time period is repeated.



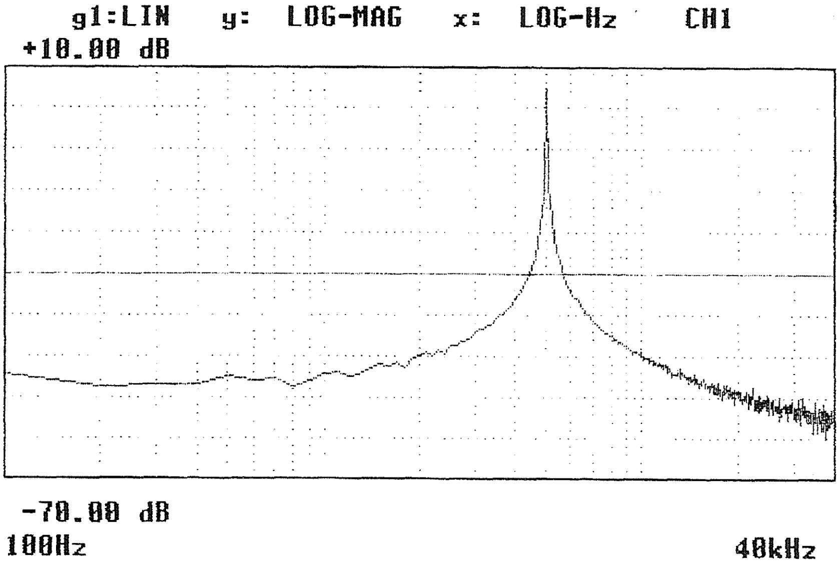
Due to the phase difference between the beginning and end portions of the waveform of the stored signal, the waveform acquired by the FFT analyzer differs from the waveform of the actual input signal.

(2) Leakage error

- Differences between the waveform of the signal acquired by the FFT algorithm and the waveform of the actual signal increase the error in the calculation results. This error is called leakage.
- Leakage error is caused by the fact that the values of the beginning and end points of the acquired (limited time period) signal acquired by the FFT analyzer are inconsistent.



Spectrum Having Small Leakage
The width of the spectrum is narrow.

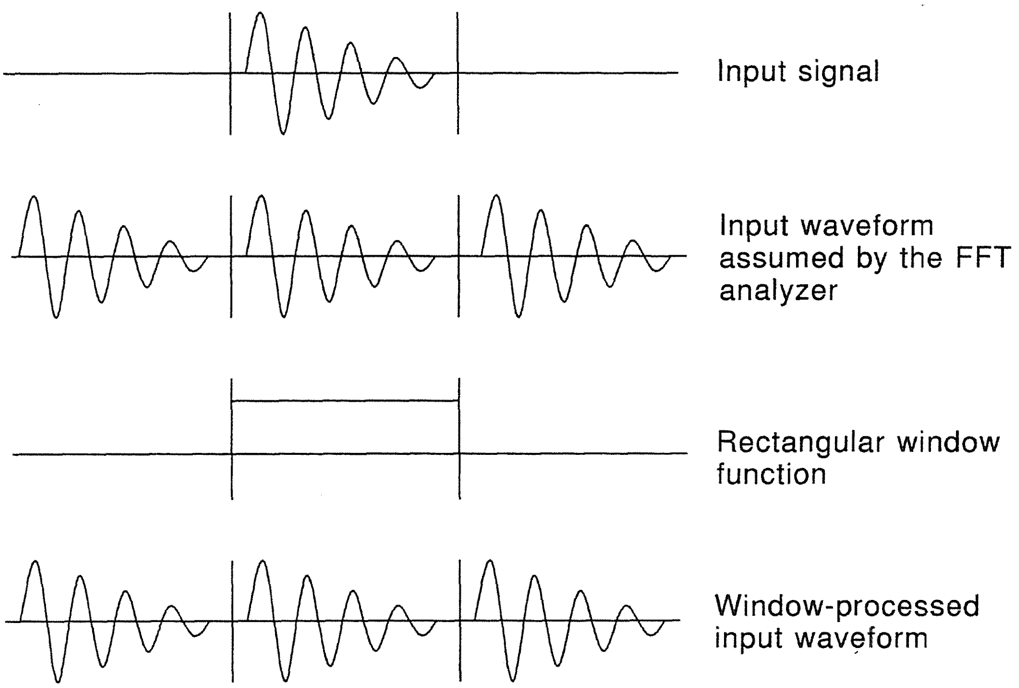


Spectrum Having Large Leakage
The spectrum spreads over a wide frequency range.

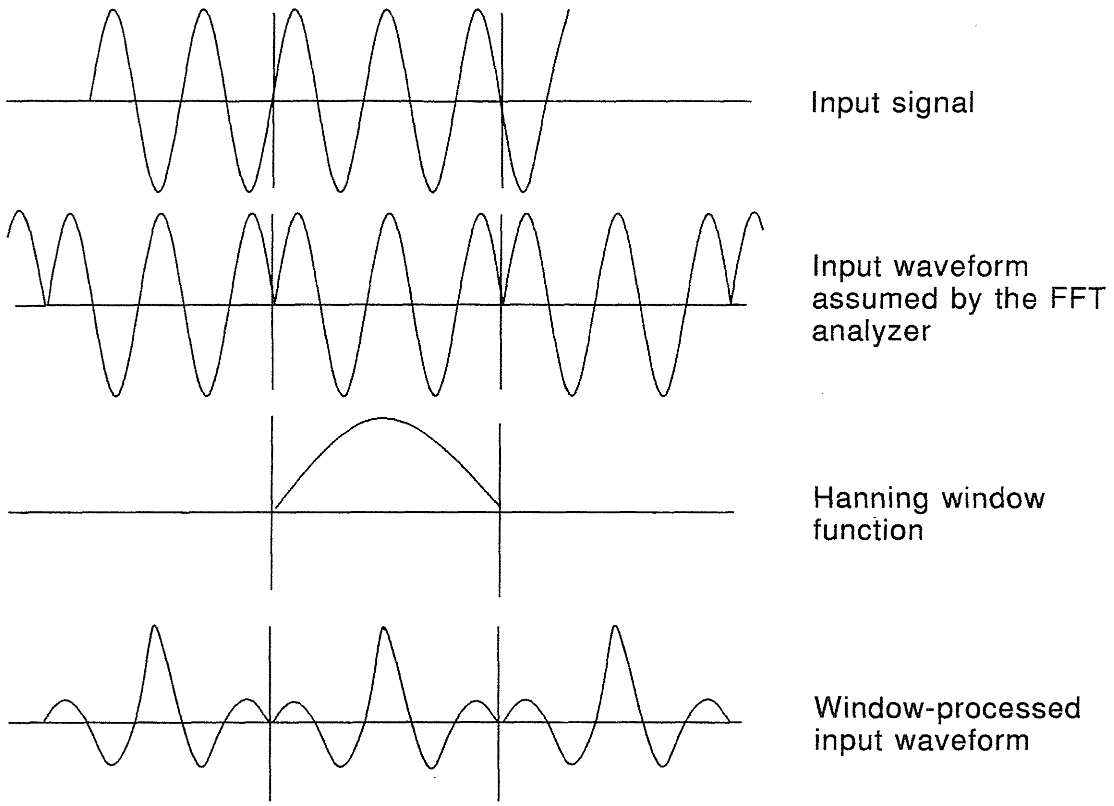
(3) Window function

- When sampling an input signal over a limited time period, the leakage error can be reduced by modifying the input signal as it is sampled.
- For example, for input of a periodic function such as that shown in the figure below, a spectrum having a small leakage error can be obtained by performing an FFT operation on the middle portion of the clocked-in waveform.
- The function applied to the input values when clocking in the input signal is referred to as window function.
- To reduce the leakage error, an effective window function must be selected according to the type of signal being measured.
- Window functions that are typically used include the Hanning, rectangular, flat-top, minimum, force, and exponential functions. For the 8840, the Hanning, rectangular, and exponential window functions are used.
- Basically, the "rectangular" window is effective for single waveforms, the "Hanning" window is effective for continuous waveforms and the "exponential" window is effective for attenuated waveforms.

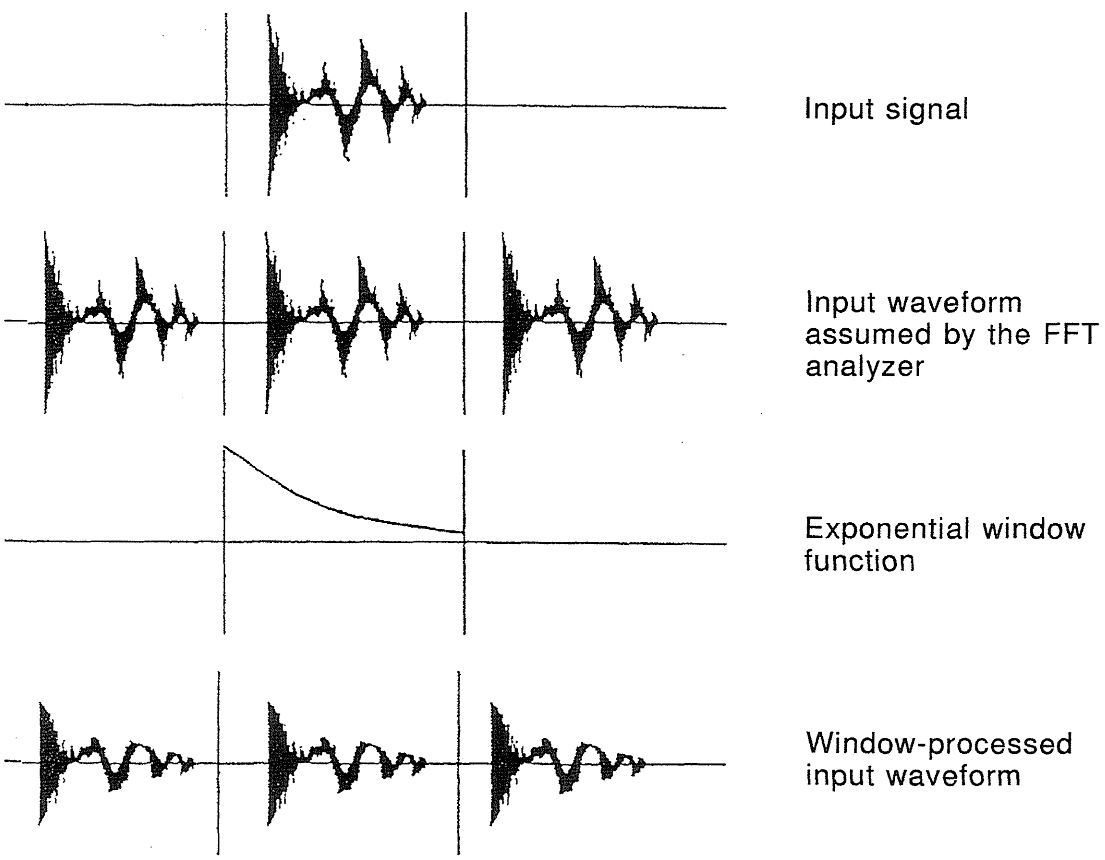
● Rectangular window



- Hanning window



- Exponential window



Chapter 2
Analysis Functions

2.1 [STR] : Storage waveform

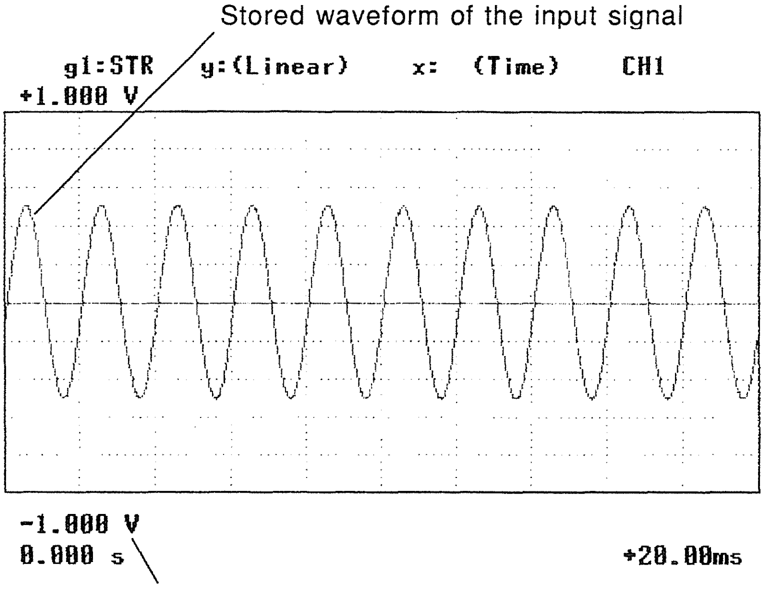
■ Displays the time domain waveform of the input signal.

Function *fa*

Vertical axis	Meaning
Linear Real (real-number part)	—
Linear Imag (imaginary-number part)	—
Linear Mag (magnitude)	fa
Log Mag (logarithmic magnitude)	—
Phase (phase)	—

Horizontal axis	Time	Time axis display The same as the memory recorder. Indicates the value of the specified TIME/DIV frequency range.
Vertical axis	Linear Mag	Indicates the value of the measurement range of the input unit in voltage units.

● Example of stored waveform



Stored waveform of the input signal

Range of the input unit

Fig 2.1-1
Stored waveform

2.2 [LIN] :Linear spectrum

- ■ The frequency domain waveform of the input signal, including magnitude and phase information.
- ■ Major applications include:
  - · Determining the peaks of waveform frequency components
  - · Determining the levels of high and low harmonics

Function

$$\begin{aligned} Fa &= \Im(fa) \\ &= |Fa|\bullet\exp(ja) \\ &= |Fa|\bullet(\cos\angle a + j\sin\angle a) \end{aligned}$$

Vertical axis	Meaning
Linear Real (real-number part)	$\mid Fa \mid \cdot \cos\angle a$
Linear Imag (imaginary-number part)	$\mid Fa \mid \cdot \sin\angle a$
Linear Mag (magnitude)	$\mid Fa \mid$
Log Mag (logarithmic magnitude)	$20\cdot\log \mid Fa \mid$
Phase (phase)	$\angle a$

Horizontal axis	Linear Hz	Indicates the frequency spectrum in linear units. The range is from DC to the maximum frequency range value.
	Log Hz	Indicates the frequency spectrum in logarithmic units. The range is from 1/400 the maximum frequency range value to the maximum frequency range value.
	Linear Nyquist	Indicates the real-number part of the data in voltage units (Nyquist mode).
Vertical axis	Linear Real	Indicates the real-number part of the data in voltage units.
	Linear Imag	Indicates the imaginary-number part of the data in voltage units.
	Linear Mag	Indicates the data values in voltage units.
	Log Mag	Indicates the data in decibels. 0dB reference value: 1V peak
	Phase	Indicates the angle between the real and imaginary-number parts of the data in degrees. This expresses the phase component.
	Linear Nyquist	Indicates the imaginary-number part of the data in voltage units (Nyquist mode).

Examples of linear spectra

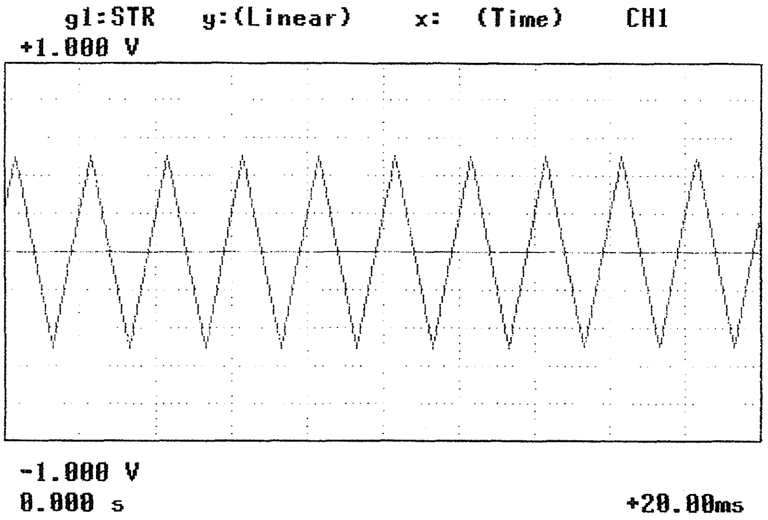


Fig. 2.2-1
Stored waveform

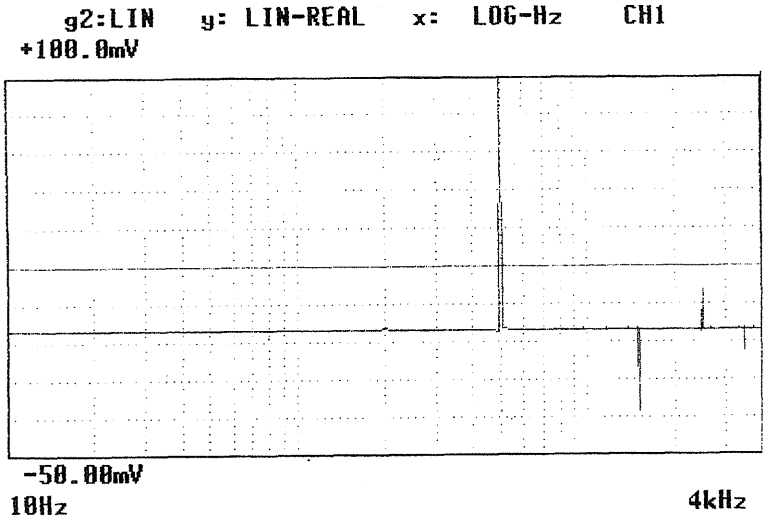


Fig. 2.2-2
LIN-REAL
(X-axis:log)

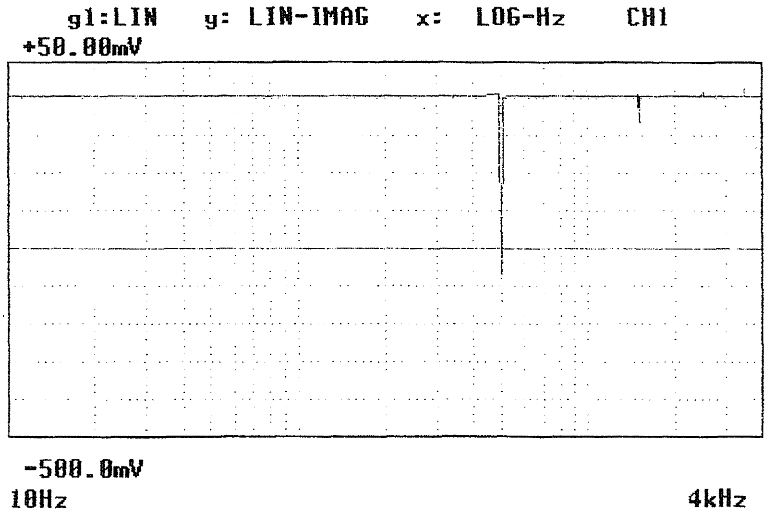


Fig. 2.2-3
LIN-IMAG
(X-axis:log)

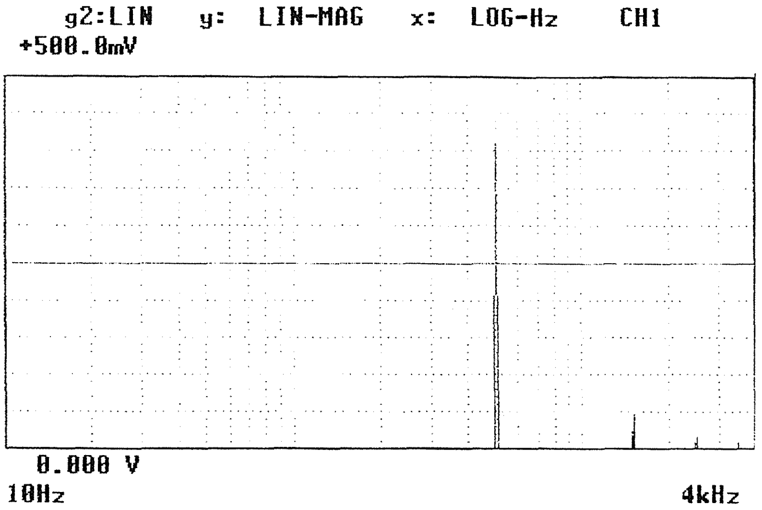


Fig. 2.2-4
LIN-MAG
(X-axis:log)

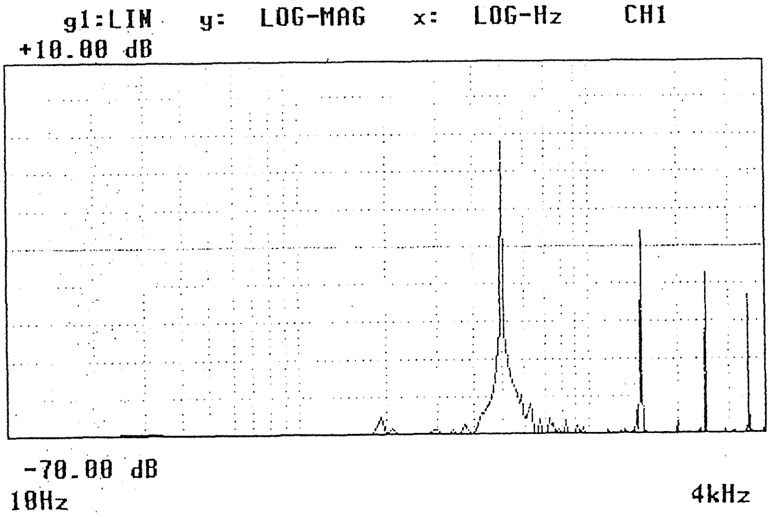


Fig. 2.2-5
LOG-MAG
(X-axis:log)

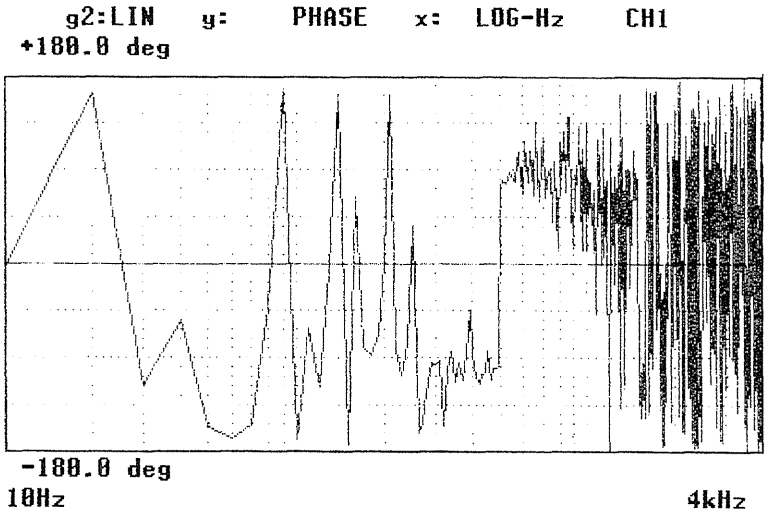


Fig. 2.2-6
PHASE
(X-axis:log)

2.3 [RMS] : RMS spectrum

- Displays the frequency domain waveform of the input signal, including magnitude (effective value) and phase information.
- Major applications include:
  - Determining the peaks of waveform frequency components.
  - Determining the effective values of frequency components.

Function

$$Ra = \frac{Fa}{\sqrt{2}}$$
$$= |Ra| \cdot \exp(ja)$$
$$= |Ra| \cdot (\cos\angle a + j\sin a)$$

DC components:
$Ra = Fa$

Vertical axis	Meaning
Lenar Real (real-number part)	$\mid Ra \mid \cdot \cos \angle a$
Linear Imag (imaginary-number part)	$\mid Ra \mid \cdot \sin \angle a$
Linear Mag (magnitude)	$\mid Ra \mid$
Log Mag (logarithmic magnitude)	$20 \cdot \log \mid Ra \mid$
Phase (phase)	$\angle a$

Horizontal axis	Linear Hz	Indicates the frequency spectrum in linear units. The range is from DC to the maximum frequency range value.
	Log Hz	Indicates the frequency spectrum in logarithmic units. The range is from 1/400 the maximum frequency range value to the maximum frequency range value.
Vertical axis	Linear Real	Indicates the real-number part of the data in voltage units.
	Linear Imag	Indicates the imaginary-number part of the data in voltage units.
	Linear Mag	Indicates the data values in voltage units.
	Log Mag	Indicates the data in decibels. 0dB reference value : 1Vrms
	Phase	Indicates the angle between the real and imaginary-number parts of the data in degrees.

- **Examples of linear spectra**

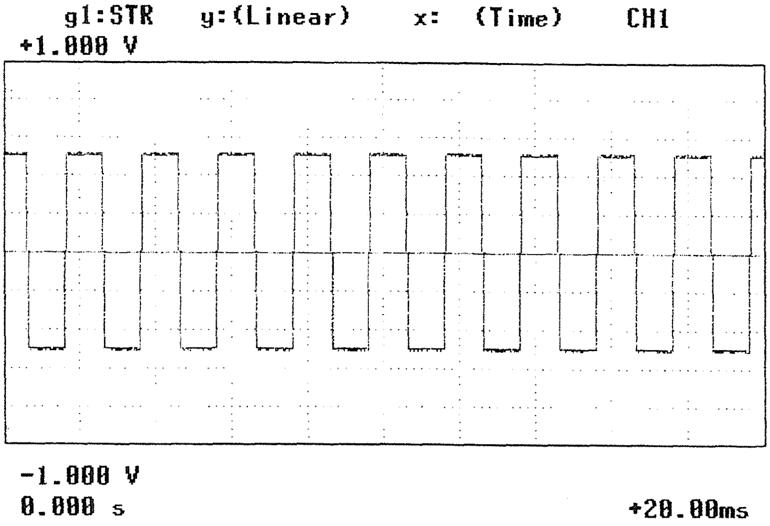


Fig. 2.3-1
Stored waveform

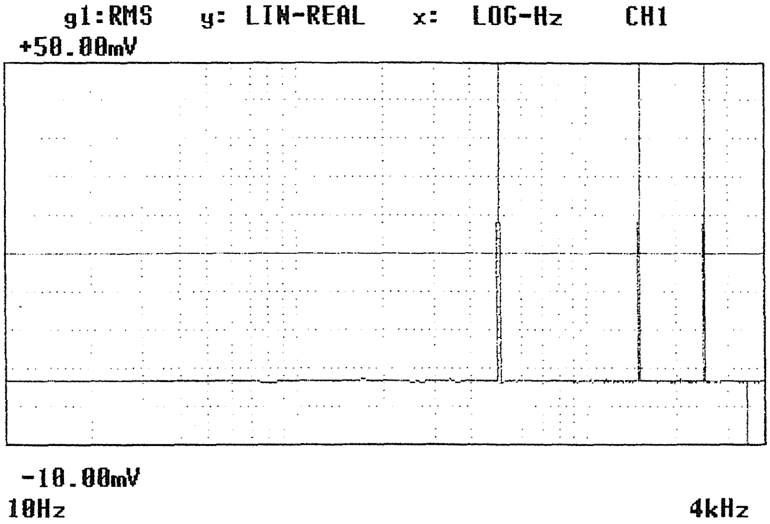


Fig. 2.3-2
LIN-REAL
(X-axis:log)

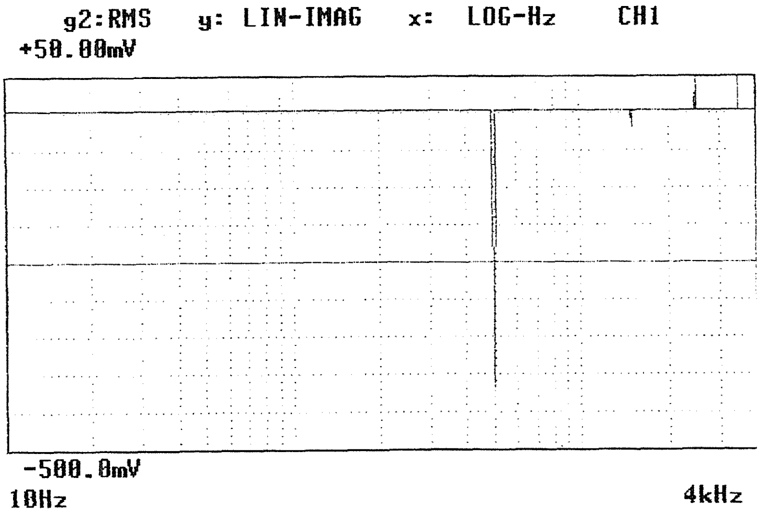


Fig. 2.3-3
LIN-IMAG
(X-axis:log)

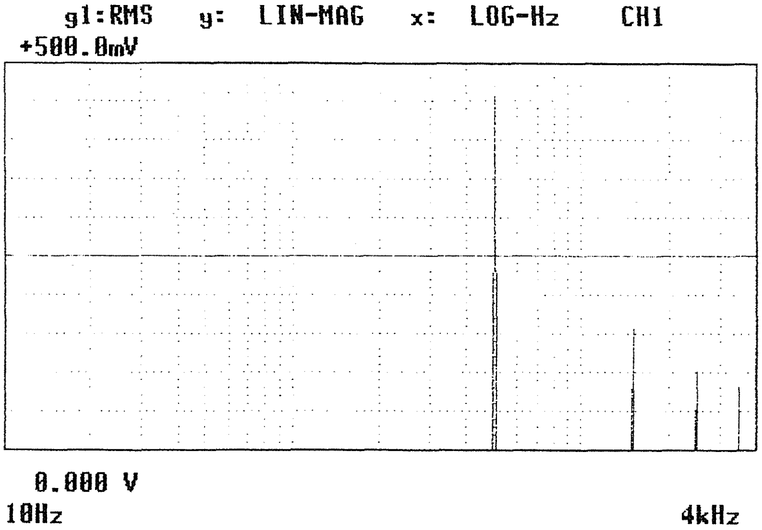


Fig. 2.3-4
LIN-MAG
(X-axis:log)

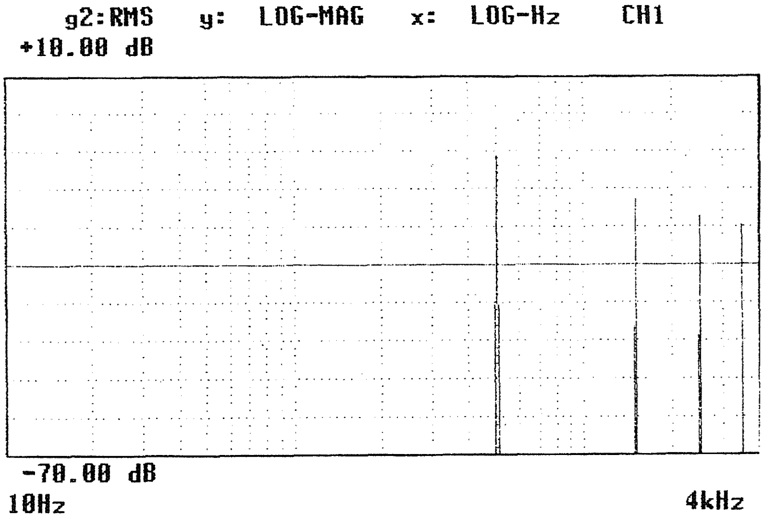


Fig. 2.3-5
LOG-MAG
(X-axis:log)

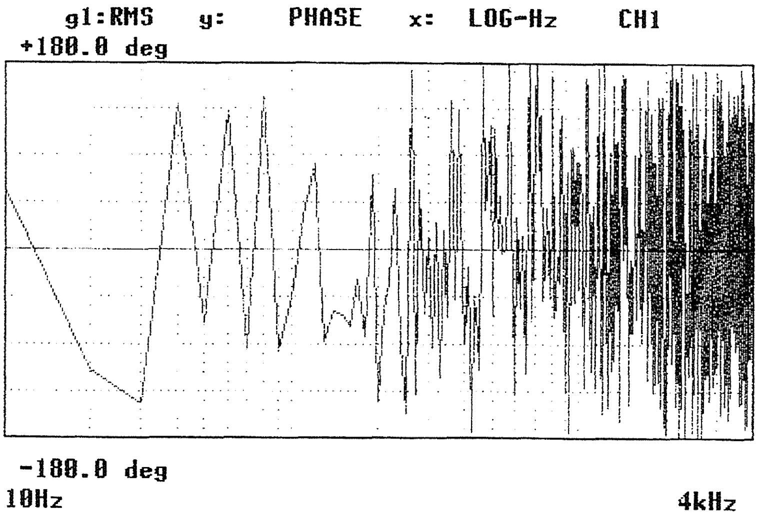


Fig. 2.3-6
PHASE
(X-axis:log)

2.4 [PSP] : Power spectrum

- ■ Displays the energy spectrum of the input signal, consisting of only magnitude information.
- ■ Major applications include:
- · Determining the peaks of waveform frequency components
- · Determining the energy levels of high and low harmonics

Function

$$\begin{aligned} Gaa &= \frac{1}{2} \cdot Fa^{*} \cdot Fa \\ &= \frac{1}{2} \cdot \{Re^{2}(Fa) + Im^{2}(Fa)\} \\ &= \frac{1}{2} \cdot |Fa|^{2} \end{aligned}$$

DC components:

$$\begin{aligned} Gaa &= Fa^{*} \cdot Fa \\ &= Re^{2}(Fa) + Im^{2}(Fa) \\ &= |Fa|^{2} \end{aligned}$$

Vertical axis	Meaning
Linear Real (real-number part)	—
Linear Imag (imaginary-number part)	—
Linear Mag (magnitude)	Gaa
Log Mag (logarithmic magnitude)	10 · log(Gaa)
Phase (phase)	—

Horizontal axis	Linear Hz	Indicates the frequency spectrum in linear units. The range is from DC to the maximum frequency range value.
	Log Hz	Indicates the frequency spectrum in logarithmic units. The range is from 1/400 the maximum frequency range value to the maximum frequency range value.
Vertical axis	Linear Mag	Indicates the binary exponential value of the data in voltage units (voltage)× (voltage). This indicates the energy component of the signal.
	Log Mag	Indicates the data in decibels. 0dB reference value: 1V^{2}rms This indicates the energy component of the signal.

- **Examples power spectra**

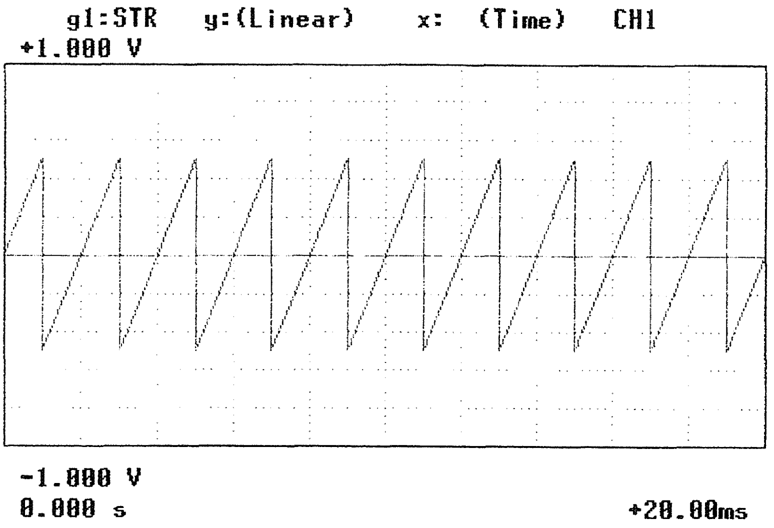


Fig. 2.4-1
Stored waveform

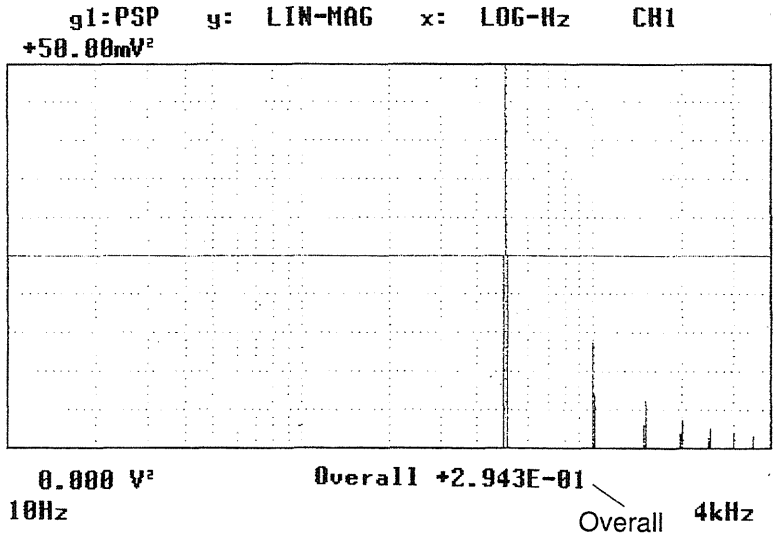


Fig. 2.4-2
LIN-MAG
(X-axis:log)

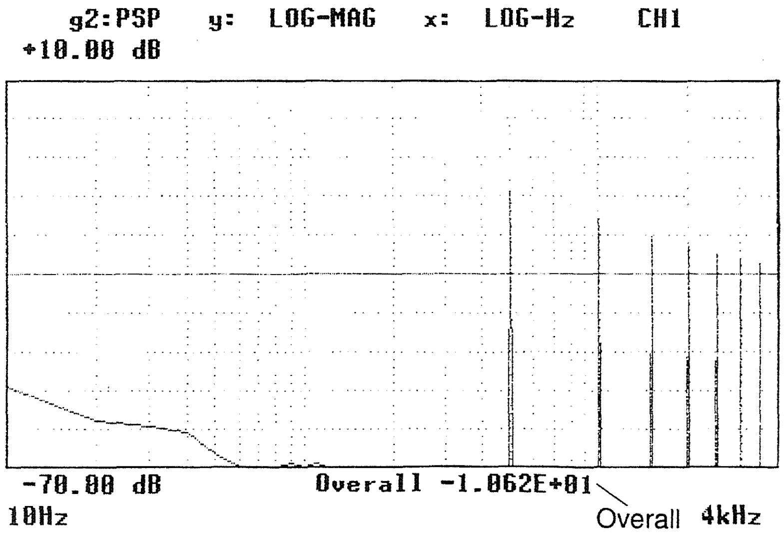


Fig. 2.4-3
LOG-MAG
(X-axis:log)

● About the overall value

- The overall value is the total effective value obtained from the frequency spectrum contained in the input signal.
- The overall value is obtained by taking the square root of the total of power spectra for all frequencies.

$$(\text{Overall value}) = \sqrt{PSPo + \sum_{i=1} PSPi} \qquad (\text{Vrms})$$

PSPo	DC component
PSPi	ith AC component

Note Power compensation values for different window types:

- Window compensation values obtained from 1000 waveforms are applied prior to FFT calculation,and PSPo and PSPi include these values.

Window compensation value : γ

Rectangular	$\gamma = 1$
Hanning	$\gamma = \sqrt{\frac{8}{3}}$
Exponential	$\gamma = \sqrt{\frac{2\log(a/100)}{(a/100)^2 - 1}}$

(a : percentage $0 \leqq a < 100$)

- With the exponential window function, setting a=0 results in a calculation based on a=0.1.

2.5 [ACR]: Auto correlation

- Displays the degree of similarity between two points in the input signal separated by time difference (τ).
- Major applications:
  - Detecting a periodic signal contained in a noisy signal with an improvement in signal-to-noise ratio.
  - Checking the periodic signal components contained in a noisy waveform, and periodic noise.

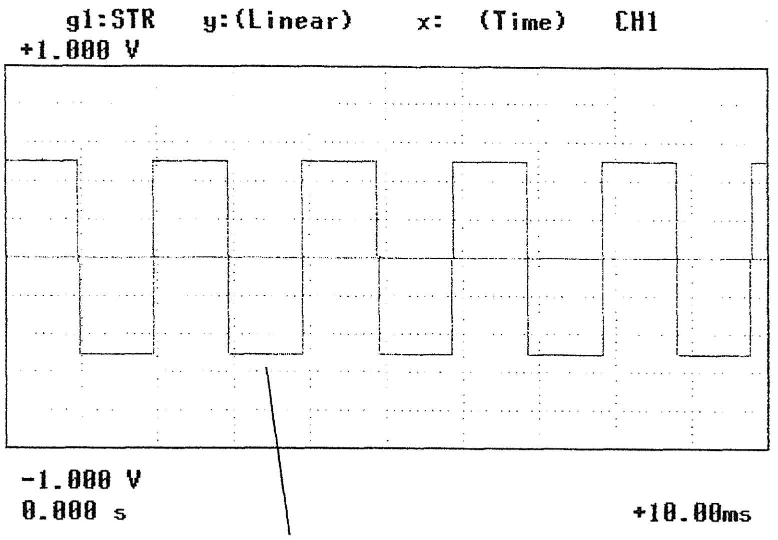
Function

$$Raa(\tau) = \Im^{-1}(Gaa)$$
$$= \frac{1}{2\pi} \int_{-\infty}^{+\infty} Gaa(\omega) \cdot \exp(j\omega\tau) d\omega$$

Vertical axis	Meaning
Linear Real (real-number part)	—
Linear Imag (imaginary-number part)	—
Linear Mag (magnitude)	Raa
Log Mag (logarithmic magnitude)	—
Phase (phase)	—

Horizontal axis	Time	Displays the time differential on a linear scale. The center indicates the reference (τ =0), the right side indicates time lag (+ τ), and the left side indicates time lead (- τ).
Vertical axis	Linear Mag	Displays the correlation coefficient on a linear scale. Readings are between +1 and -1 (without units). +1 indicates the highest similarity for time differential τ , and 0 indicates the lowest similarity. -1 indicates that the polarity is completely opposite. Due to the characteristics of the function, τ =0 always results in +1.

● Examples of auto correlation function waveforms



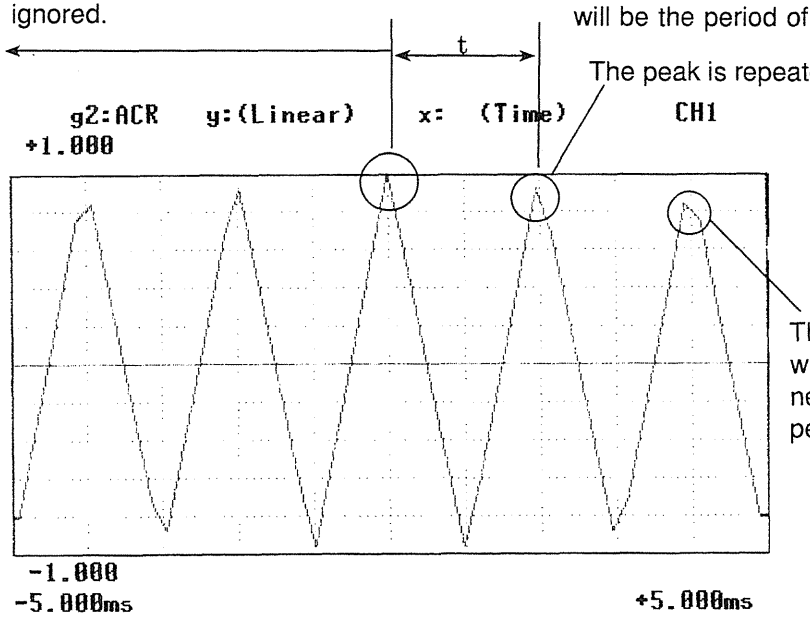
Input waveform

Fig. 2.5-1
Stored waveform

Due to the characteristics of the function, the waveform in this portion becomes the same as that in the positive direction, so that this portion can be ignored.

Time period (τ) from t = 0 to the first peak will be the period of the input signal.

The peak is repeated at a certain interval.



The periodicity deteriorates with time. It is only necessary to look at the first peak in the graph.

Fig. 2.5-2
Auto correlation function

2.6 [HIS]: Histogram

- ■ Displays the frequencies of the magnitudes of sampled points.
- ■ Major applications include:
  - Determining waveform imbalance
  - Determining whether a waveform is artificial or natural from the waveform distribution (most natural waveforms are regular sine waves).

Function *Pa*

Vertical axis	Meaning
Linear Real (real-number part)	—
Linear Imag (imaginary-number part)	—
Linear Mag (magnitude)	Pa
Log Mag (logarithmic magnitude)	—
Phase (phase)	—

Horizontal axis	Volt	Measurement range of the input unit.
Vertical axis	Linear Mag	Number of sample points for the time axis data (total: 1000 points).

● Examples of histogram waveforms

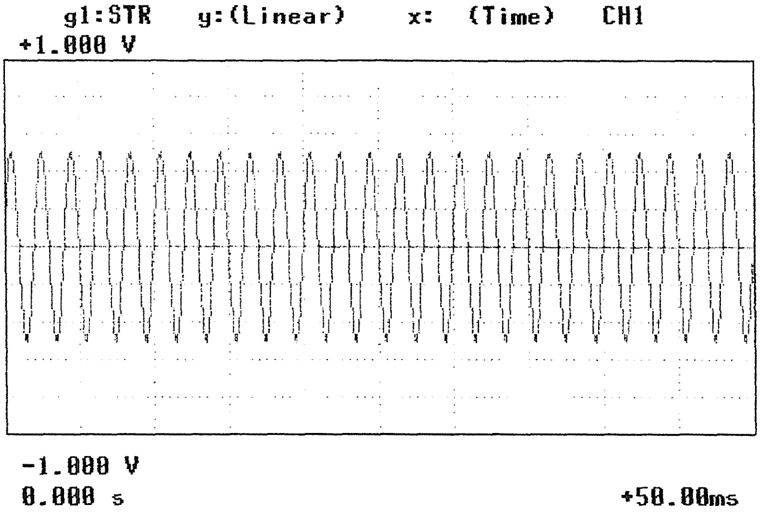


Fig. 2.6-1
Stored waveform

Number of sample points

From this, it is clear that the data has a majority of points with large amplitudes.

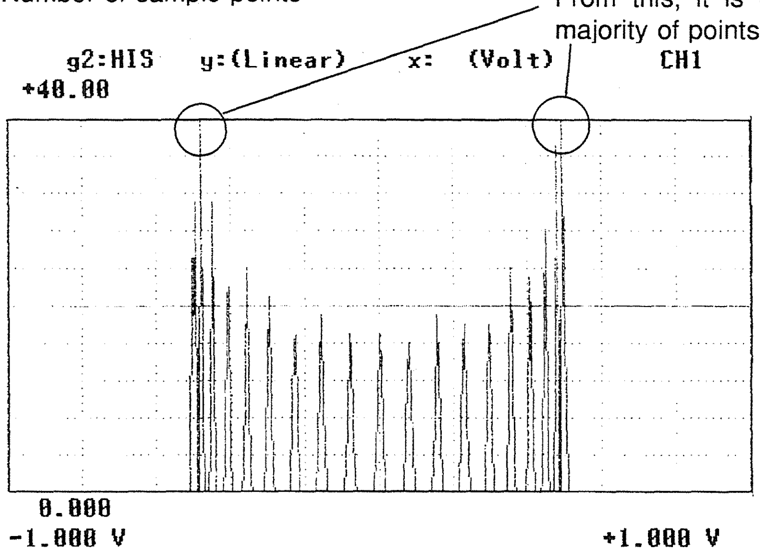


Fig. 2.6-2
Histogram

2.7 [TRF] : Transfer function

- Displays the transfer function (frequency characteristics) of the system being measured calculated from input and output signals.
- Nyquist diagrams can also be displayed, including magnitude and phase information.
- Major applications include:
  - Determining filter frequency characteristics.
  - Determining feedback control system stability through Nyquist diagrams.
  - Determining the physical resonant frequency using an impulse hammer and pick-up sensor.

Function

$$Hab = \frac{Fb}{Fa} = \frac{Fb \cdot Fa^{*}}{Fa \cdot Fa^{*}} = \frac{Gab}{Gaa}$$

$$= \frac{|Gab|}{|Gaa|}\{\cos(\angle b - \angle a) + j\sin(\angle b - \angle a)\}$$

Vertical axis	Meaning
Linear Real (real-number part)	$\mid Hab \mid \cdot \cos(\angle b - \angle a)$
Linear Imag (imaginary-number part)	$\mid Hab \mid \cdot \sin(\angle b - \angle a)$
Linear Mag (magnitude)	$\mid Hab \mid$
Log Mag (logarithmic magnitude)	$20 \cdot \log \mid Hab \mid$
Phase (phase)	$\angle b - \angle a$

Horizontal axis	Linear Hz	Indicates the frequency spectrum in linear units. The range is from DC to the maximum frequency range value.
	Log Hz	Indicates the frequency spectrum in logarithmic units. The range is from 1/400 the maximum frequency range value to the maximum frequency range value.
	Linear Nyquist	Indicates the real-number part of the input-to-output ratio (Nyquist mode).
Vertical axis	Linear Real	Indicates the real-number part of the input-to-output ratio (No units).
	Linear Imag	Indicates the imaginary-number part of the input-to-output ratio (No units).
	Linear Mag	Indicates the input-to-output ratio in decibels (No units). This expresses the magnitude component.
	Log Mag	Indicates the input-to-output ratio in decibels (No units). This expresses the magnitude component.
	Phase	Indicates the angle between the real and imaginary-number parts of the data in degrees. This expresses the phase component.
	Linear Nyquist	Indicates the imaginary-number part of the input-to-output ratio (Nyquist mode).

- **Examples of transfer function waveforms**

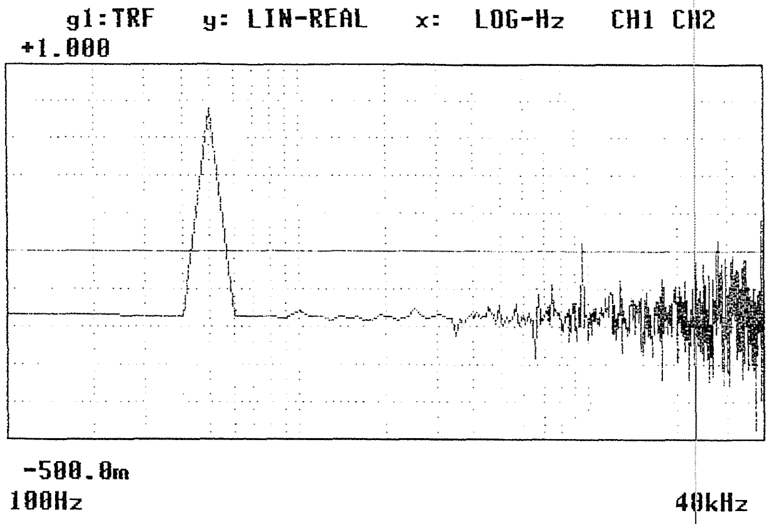


Fig. 2.7-1
LIN-REAL
(X-axis: log)

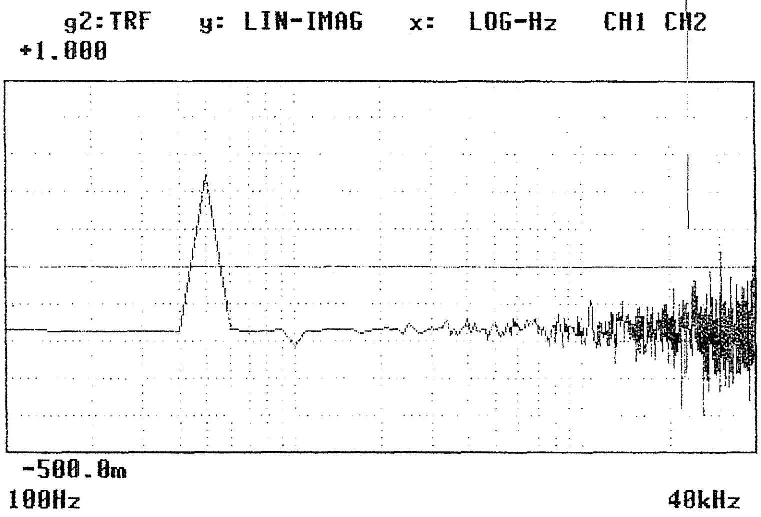


Fig. 2.7-2
LIN-IMAG
(X-axis: log)

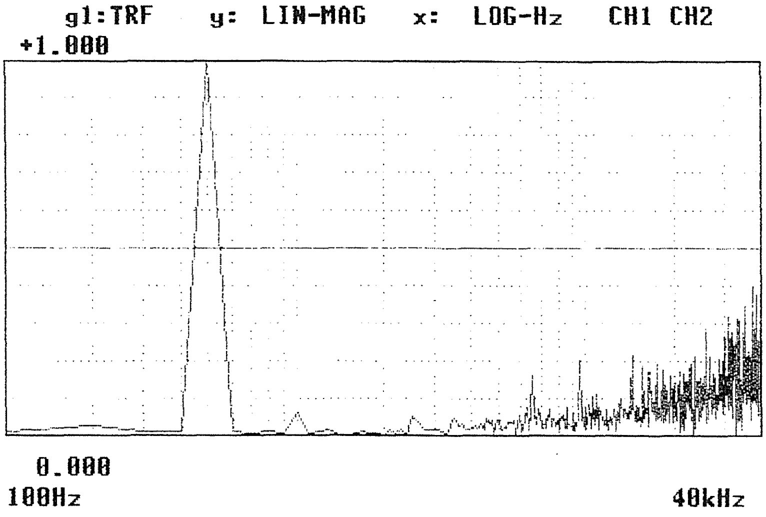


Fig. 2.7-3
LIN-MAG
(X-axis: log)

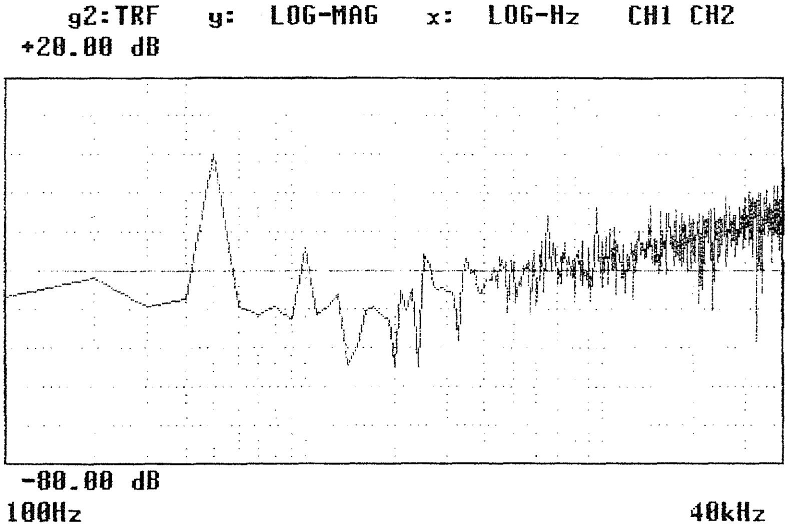


Fig. 2.7-4
LOG-MAG
(X-axis: log))

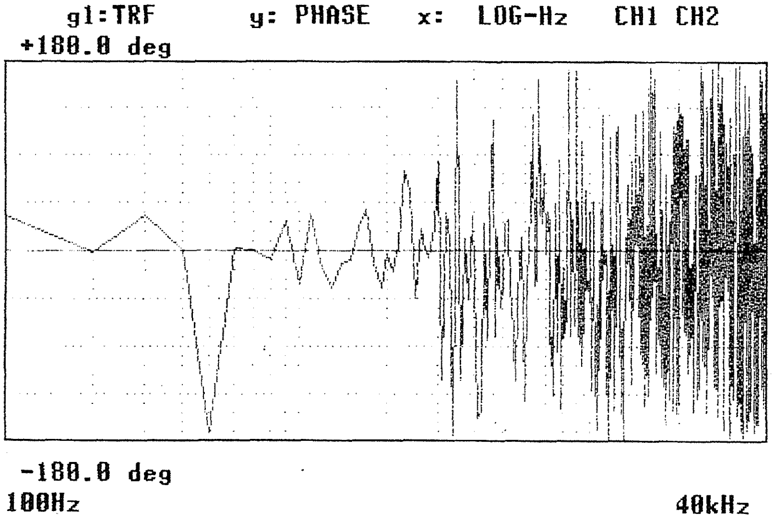


Fig. 2.7-5
PHASE
(X-axis: log))

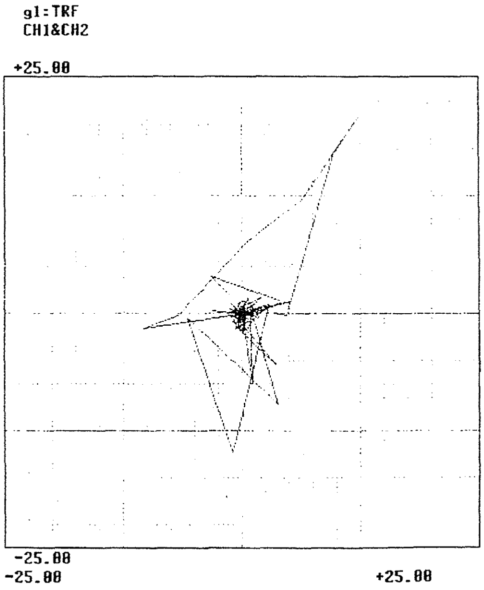


Fig. 2.7-6
Nyquist

2.8 [CSP]: Cross power spectrum

- Displays the product of the spectra of two input signals.
- The magnitude and phase information of the frequency components that are common to both signals can be displayed.
- Major applications:
  - Obtaining frequency components common to both signals.

Function

$$Gab = \frac{1}{2} \cdot Fa^* \cdot Fb$$

$$= \frac{1}{2} \cdot |Fa| \cdot |Fb| \{\cos(\angle b - \angle a) + j\sin(\angle b - \angle a)\}$$

DC components;

$$Gab = Fa^* \cdot Fb$$

Vertical axis	Meaning
Linear Real (real-number part)	$\mid Gab \mid \cdot \cos(\angle b - \angle a)$
Linear Imag (imaginary-number part)	$\mid Gab \mid \cdot \sin(\angle b - \angle a)$
Linear Mag (magnitude)	$\mid Gab \mid$
Log Mag (logarithmic magnitude)	$10 \cdot \log \mid Gab \mid$
Phase (phase)	$\angle b - \angle a$

Horizontal axis	Linear Hz	Indicates the frequency spectrum in linear units. The range is from DC to the maximum frequency range value.
	Log Hz	Indicates the frequency spectrum in logarithmic units. The range is from 1/400 the maximum frequency range value to the maximum frequency range value.
	Linear Nyquist	Indicates the real-number part of the data in voltage units (Nyquist mode).
Vertical axis	Linear Real	Indicates the real-number part of the data in voltage units.
	Linear Imag	Indicates the imaginary-number part of the data in voltage units.
	Linear Mag	Indicates the binary exponential value of the data in voltage units. Interlocked with the amplifier range..
	Log Mag	Indicates the data in decibels. 0dB reference value; 1Vrms. This expresses the magnitude component.
	Phase	Indicates the angle between the real and imaginary-number parts of the data in degrees. This expresses the phase component.
	Linear Nyquist	Indicates the imaginary-number part of the data in voltage units (Nyquist mode).

- **Examples of cross power spectra**

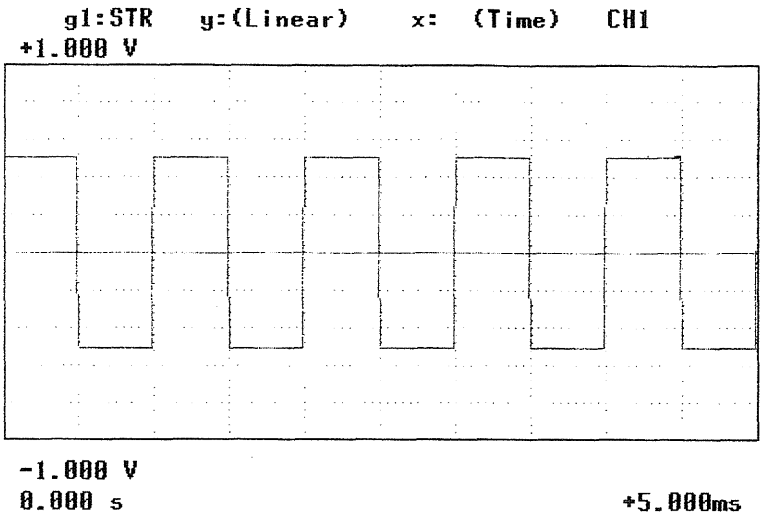


Fig. 2.8-1
Stored waveform 1

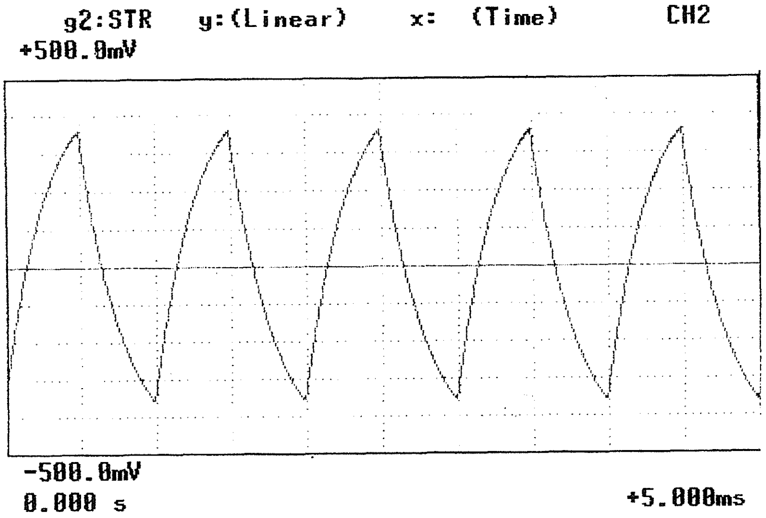


Fig. 2.8-2
Stored waveform 2

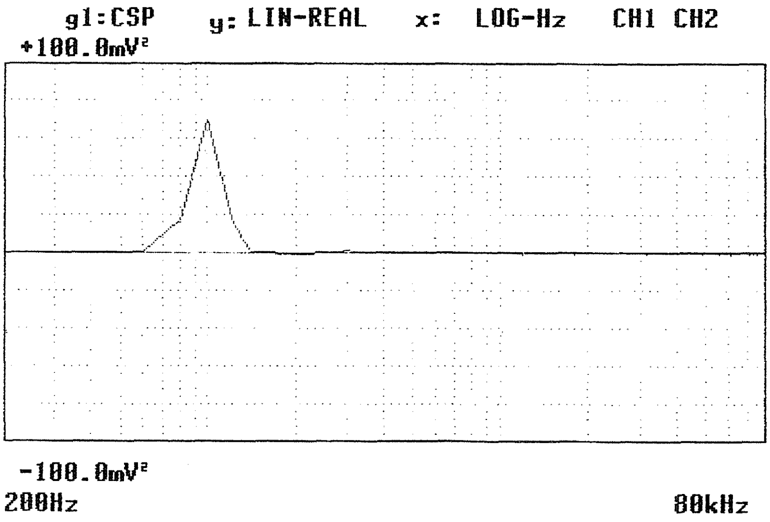


Fig. 2.8-3
LIN-REAL
(X-axis: log)

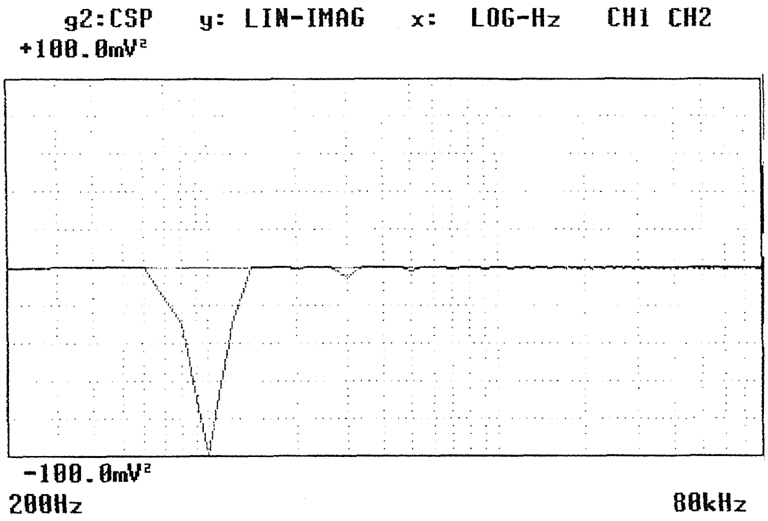


Fig. 2.8-4
LIN-IMAG
(X-axis: log)

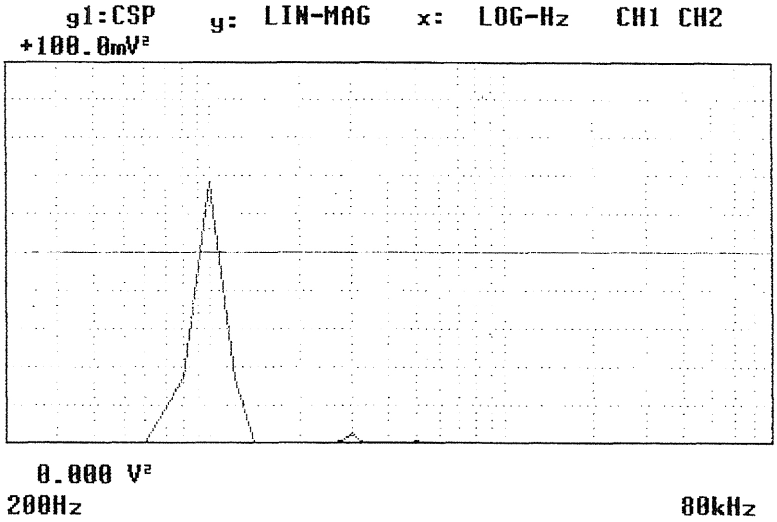


Fig. 2.8-5
LIN-MAG
(X-axis: log)

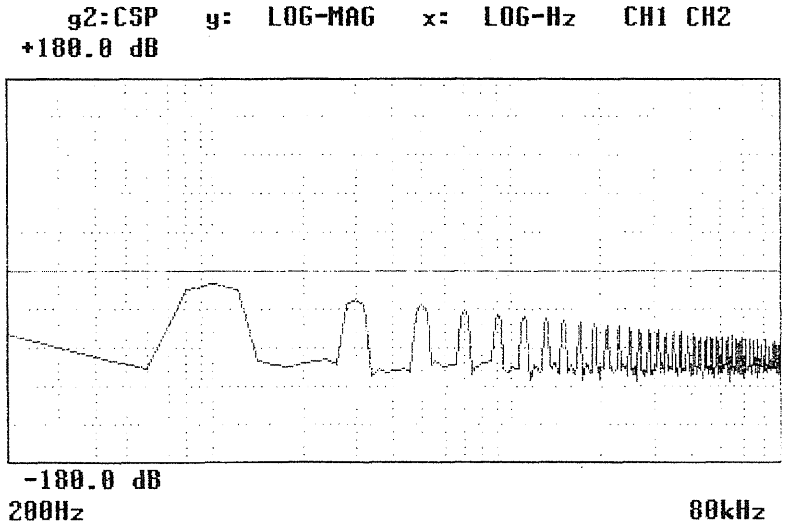


Fig. 2.8-6
LOG-MAG
(X-axis: log)

2.9 [CCR]: Cross correlation

- Displays the degree of similarity between two points separated by a time difference (τ) on two signals.
- The degree of similarity is expressed as a function of the time difference (τ).
- Major applications:
  - Obtaining the phase difference between two signals in time units.
  - Obtaining a speed or distance by measuring the time delay.

Function

$$Rab(\tau) = \Im^{-1}(Gab)$$
$$= \frac{1}{2\pi}\int_{-\infty}^{+\infty} Gab(\omega) \bullet \exp(j\omega\tau)d\omega$$

Vertical axis	Meaning
Linear Real (real-number part)	—
Linear Imag (imaginary-number part)	—
Linear Mag (magnitude)	Rab
Log Mag (logarithmic magnitude)	—
Phase (phase)	—

Horizontal axis	Time	Displays the time differential on a linear scale. The center indicates the reference (τ =0), the right side indicates time lag (+ τ), and the left side indicates time lead (- τ).
Vertical axis	Linear Mag	Displays the correlation coefficient on a linear scale. Readings are from +1 to -1 (no units). +1 indicates the highest similarity between the input and output signals for time differential τ , and 0 indicates the lowest similarity. -1 indicates that the polarity is completely opposite.

- **Examples of cross-correlation function waveforms**

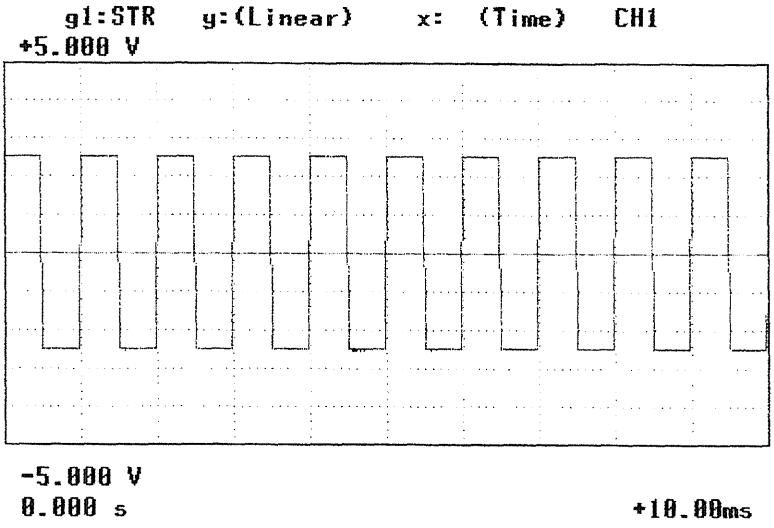


Fig. 2.9-1

Stored waveform (Input signal)

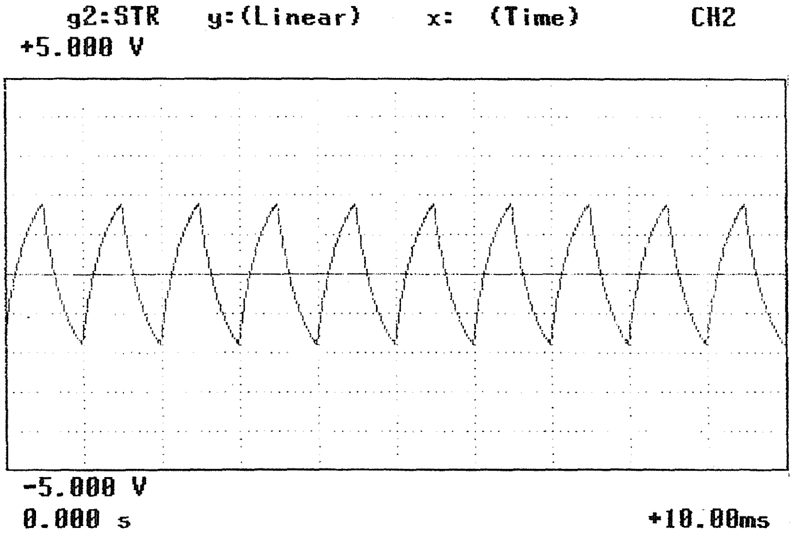


Fig. 2.9-2

Stored waveform (Output signal)

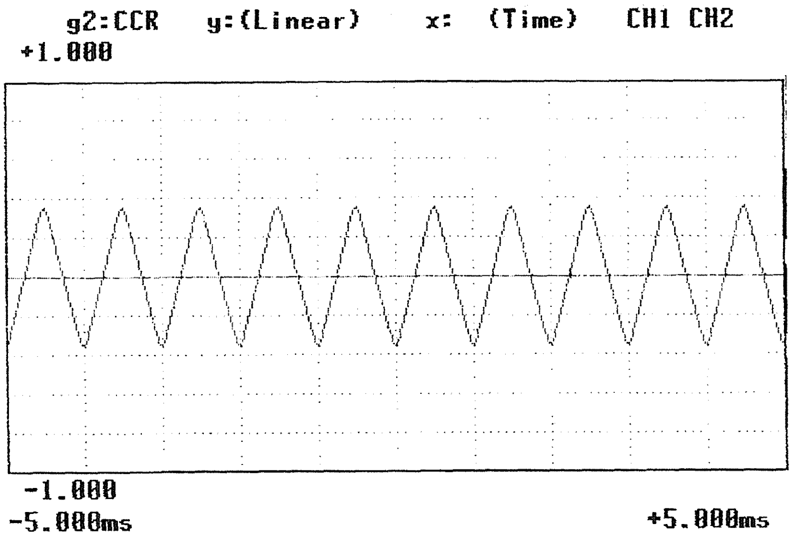


Fig. 2.9-3

Cross-correlation function

2.10 [IMP] : Unit impulse response

- Displays the frequency response of a system in the time domain.
- A response waveform equivalent to the unit impulse function is obtained by analyzing the input and output signals of the system being measured.
- Major applications; Checking circuit time constants.

Function $IMP = \Im^{-1}(Hab)$

Vertical axis	Meaning
Linear Real (real-number part)	—
Linear Imag (imaginary-number part)	—
Linear Mag (magnitude)	IMP
Log Mag (logarithmic magnitude)	—
Phase (phase)	—

Horizontal axis	Time	Displays the time differential on a linear scale. The center indicates the reference (τ), the the right side indicates time lag (+ τ), and the left side indicates time lead(- τ).
Vertical axis	Linear Mag	Inverse Fourier conversion value of the transfer function (Hab) (no units).

● Examples of unit impulse response waveforms

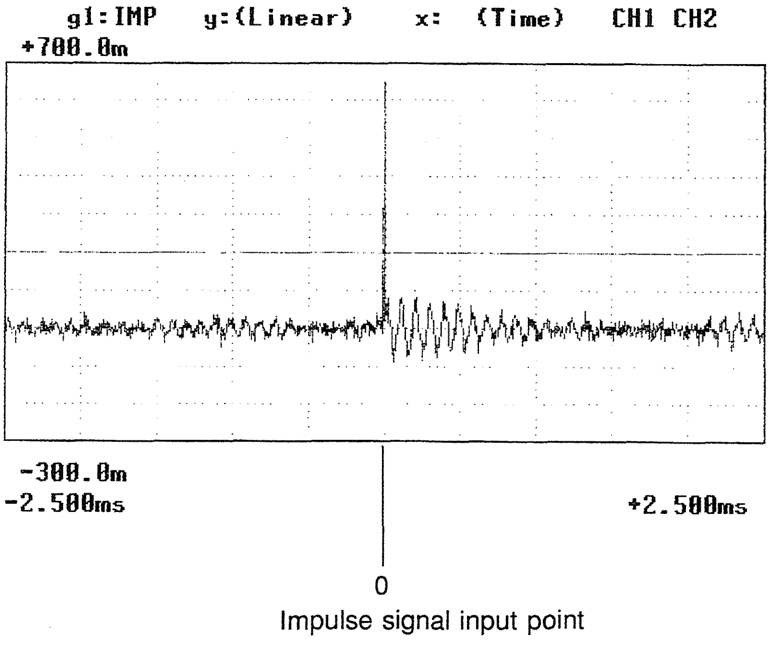


Fig. 2.10-1
Unit impulse response

2.11 [COH] : Coherence

- ■ Displays the output signal component that is coherent (interference possible) to the input signal, yielding a value from 0 to 1.
- ■ Major applications include:
  - · Evaluation of transfer functions.
  - · Determining the contribution of individual input lines to the output of multi-input systems.

Function

$$COH = \frac{Gab^{*} \cdot Gab}{Gaa \cdot Gbb}$$

Vertical axis	Meaning
Linear Real (real-number part)	—
Linear Imag (imaginary-number part)	—
Linear Mag (magnitude)	COH
Log Mag (logarithmic magnitude)	—
Phase (phase)	—

Horizontal axis	Linear Hz	Indicates the frequency spectrum in linear units. The range is from DC to the maximum frequency range value.
	Log Hz	Indicates the frequency spectrum in logarithmic units. The range is from 1/400 the maximum frequency range value to the maximum frequency range value.
Vertical axis	Linear Mag	Indicates the relationship between the two input signals. The degree of relationship is indicated from 0 to 1 on a linear scale (no units).

Note For a single measurement, the coherence function returns 1 for all frequencies. When measuring, be sure to use frequency averaging.

● Examples of coherence function waveforms

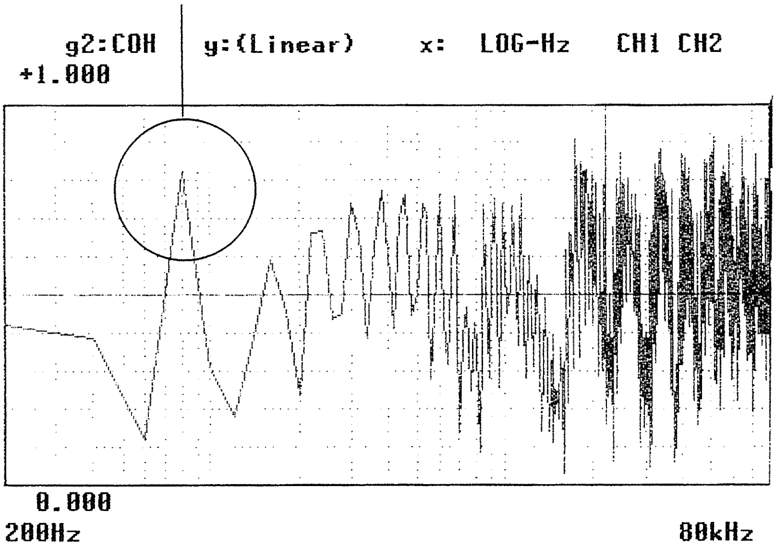

The signals are closely related at this frequency.

Fig. 2.11-1
Coherence function

2.12 [OCT] : Octave analysis

- Octave analysis is the expression of a spectrum (such as a noise spectrum) as a sound pressure level using a 1-octave band or 1/3-octave band fixed ratio band pass filter.
- Octave analysis is frequency used for analyzing the frequency content of noise.

Function *Oct*

Vertical axis	Meaning
Linear Real (real-number part)	—
Linear Imag (imaginary-number part)	—
Linear Mag (magnitude)	Oct
Log Mag (logarithmic magnitude)	20 · log (Oct)
Phase (phase)	—

Horizontal axis	1/1 Oct	Set for 1/1-octave band analysis.
	1/3 Oct	Set for 1/3-octave band analysis.
Vertical axis	Linear Mag	Octave analysis value displayed in voltage units.
	Log Mag	Octave analysis value displayed in decibels.

- Octave analysis, a kind of frequency analysis, is used to analyze noise. With octave analysis, noise is analyzed by passing it through a band pass filter with a constant ratio width of 1/1 octave band or 1/3 octave band.
- Whereas a power spectrum shows power for various bands of a fixed range of frequencies by dividing it into parts, octave analysis places the frequency axis on a logarithmic scale and uses a bar graph representation to show the power for each evenly-spaced portion of a frequency range.
- With analog octave analysis, the octave band center frequency and the filter characteristics conform to the standards set forth in the ANSI Class Ⅲspecifications.
- The analyzer first obtains the power spectra, then bundles them for 1/1-octave or 1/3-octave analysis. The following analyses are possible:
  - 5-band, 1/1-octave analysis
  - 15-band, 1/3-octave analysis
- With this analyzer, 15-band, 1/3-octave analysis conforms to the standards set forth in the ANSI Class Ⅲ specifications. Filter characteristics also conform to ANSI Class Ⅲ. However, the uppermost band of the analysis range has no leakage from higher frequencies. For example, the 20 kHz band has no leakage from the 25 kHz band.
  - 15-band, 1/3-octave analysis
    With 1/3-octave analysis, 400 spectral lines resulting from normal frequency analysis are bundled at 1/3-octave intervals and displayed as a bar graph.
  - 5-band, 1/1-octave analysis
    With 1/1-octave analysis, 400 spectral lines resulting from normal frequency analysis are bundled at 1/1-octave intervals and displayed as a bar graph.

● Examples of octave analysis waveforms

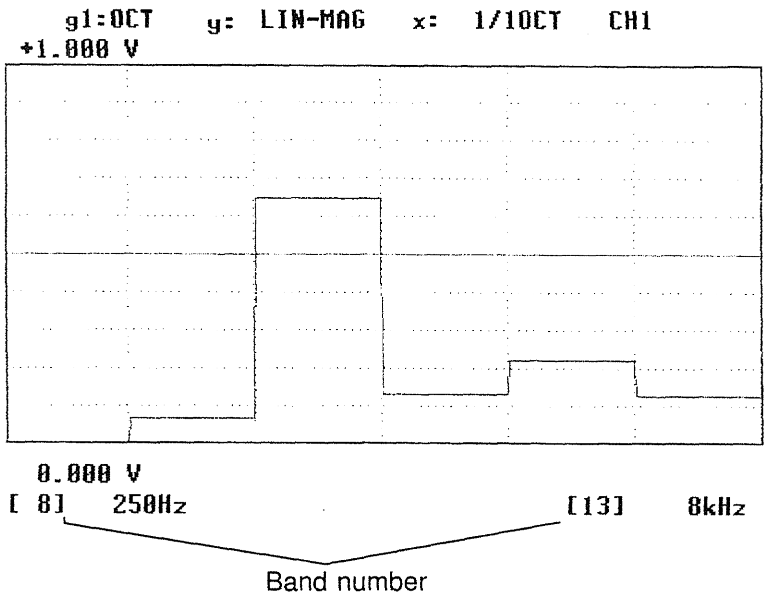


Fig. 2.12-1
1/1 Octave analysis

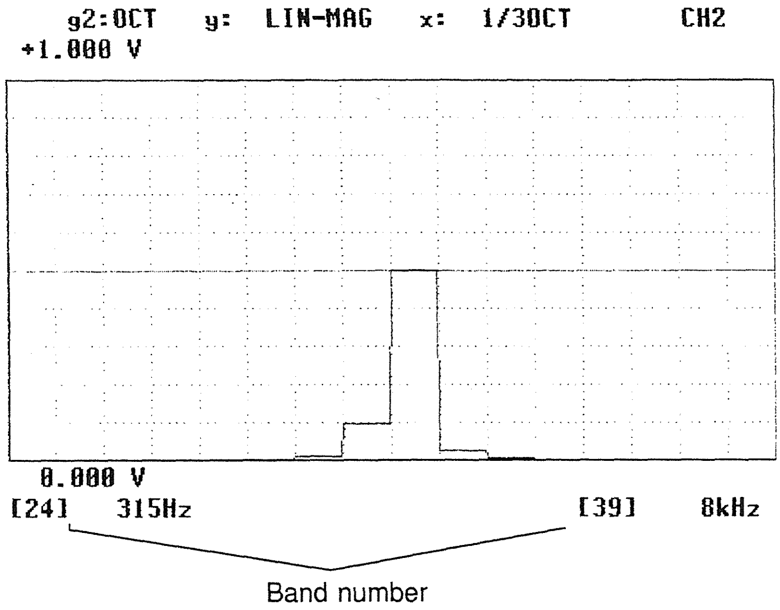


Fig. 2.12-2
1/3 Octave analysis

● Frequency ranges and measurable range widths (O: 1/3 OCT, X: 1/1 OCT)

Band No.		Center frequency (Hz)	Frequency range (Hz)																	
1/1	1/3		133 m	333 m	667 m	2	4	8	20	40	80	200	400	800	2 k	4 k	8 k	20 k	40 k	80 k
-8	-24	4 m	X																	
	-23	5 m	0X																	
-7	-22	6.3 m	0X																	
	-21	8 m	0X	X																
	-20	10 m	0X	0X																
-6	-19	12.5 m	0X	0X																
	-18	16 m	0X	0X	X															
	-17	20 m	0X	0X	0X															
-5	-16	25 m	0X	0X	0X															
	-15	31.5 m	0X	0X	0X															
	-14	40 m	0X	0X	0X															
-4	-13	50 m	0X	0X	0X															
	-12	63 m	0X	0X	0X	0X														
	-11	80 m	0X	0X	0X	0X														
-3	-10	100 m	0X	0X	0X	0X														
	-9	125 m	0X	0X	0X	0X	0X													
	-8	160 m	0	0X	0X	0X	0X													
-2	-7	200 m		0X	0X	0X	0X													
	-6	250 m		0X	0X	0X	0X	0X												
	-5	315 m		0	0X	0X	0X	0X												
-1	-4	400 m			0X	0X	0X	0X												
	-3	500 m			0X	0X	0X	0X	X											
	-2	630 m			0	0X	0X	0X	0X											
0	-1	800 m				0X	0X	0X	0X											
	0	1				0X	0X	0X	0X	X										
	1	1.25				0X	0X	0X	0X	0X										
1	2	1.6				0X	0X	0X	0X	0X										
	3	2				0X	0X	0X	0X	0X	X									
	4	2.5					0X	0X	0X	0X	0X									
2	5	3.15					0X	0X	0X	0X	0X									
	6	4					0X	0X	0X	0X	0X									
	7	5						0X	0X	0X	0X									
3	8	6.3						0X	0X	0X	0X	0								
	9	8						0X	0X	0X	0X	0X								
	10	10							0X	0X	0X	0X								
4	11	12.5							0X	0X	0X	0X	0							
	12	16							0X	0X	0X	0X	0X							
	13	20							0	0X	0X	0X	0X							
5	14	25								0X	0X	0X	0X	0						
	15	31.5								0X	0X	0X	0X	0X						
	16	40								0	0X	0X	0X	0X						
6	17	50									0X	0X	0X	0X						
	18	63									0X	0X	0X	0X	0X					
	19	80									0	0X	0X	0X	0X					
7	20	100										0X	0X	0X	0X					
	21	125										0X	0X	0X	0X	0X				
	22	160										0X	0X	0X	0X	0X				
8	23	200										0X	0X	0X	0X	0X				
	24	250										X	0X	0X	0X	0X	0X			
	25	315											0X	0X	0X	0X	0X			
9	26	400											0X	0X	0X	0X	0X			
	27	500											X	0X	0X	0X	0X	X		
	28	630												0X	0X	0X	0X	0X		
10	29	800												0X	0X	0X	0X	0X		
	30	1k												X	0X	0X	0X	0X	X	
	31	1.25k													0X	0X	0X	0X	0X	

Band No.		Center frequency (Hz)	Frequency range (Hz)																	
1/1	1/3		133 m	333 m	667 m	2	4	8	20	40	80	200	400	800	2 k	4 k	8 k	20 k	40 k	80 k
	32	1.6 k													0X	0X	0X	0X	0X	
11	33	2 k													0X	0X	0X	0X	0X	X
	34	2.5 k														0X	0X	0X	0X	0X
	35	3.15 k														0X	0X	0X	0X	0X
12	36	4 k														0X	0X	0X	0X	0X
	37	5 k															0X	0X	0X	0X
	38	6.3 k															0X	0X	0X	0X
13	39	8 k															0X	0X	0X	0X
	40	10 k																0X	0X	0X
	41	12.5 k																0X	0X	0X
14	42	16 k																0X	0X	0X
	43	20 k																0	0X	0X
	44	25 k																	0X	0X
15	45	31.5 k																	0X	0X
	46	40 k																	0	0X
	47	50 k																		0X
16	48	63 k																		0X
	49	80 k																		0

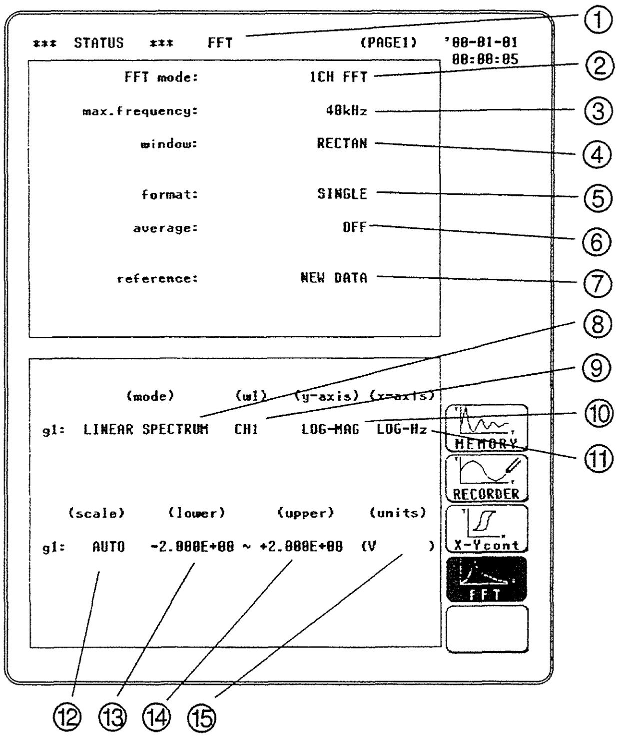
analysis

Chapter 3
Display Screens

This section describes the STATUS, CHANNEL, and DISPLAY screens, and gives references to other important parts of this manual.
For the SYSTEM screen, refer to 8840 Instruction Manual Section 13.
For the "floppy disk control" screen, refer to the 8840 Instruction Manual, Section 15.

3.1 STATUS screen

- Press the STATUS key, and page 1 of the STATUS screen appears.
- Pressing the STATUS key repeatedly cycles through the three pages of the STATUS screen. The screen page can also be changed by holding a cursor key down continuously.
- Page 1 is used to set FFT functions.
- Page 2 is used to set print, auto-save, and trigger conditions.
- Page 3 is used to set waveform decision parameters (For details refer to Section 10 of the 8840 Manual).

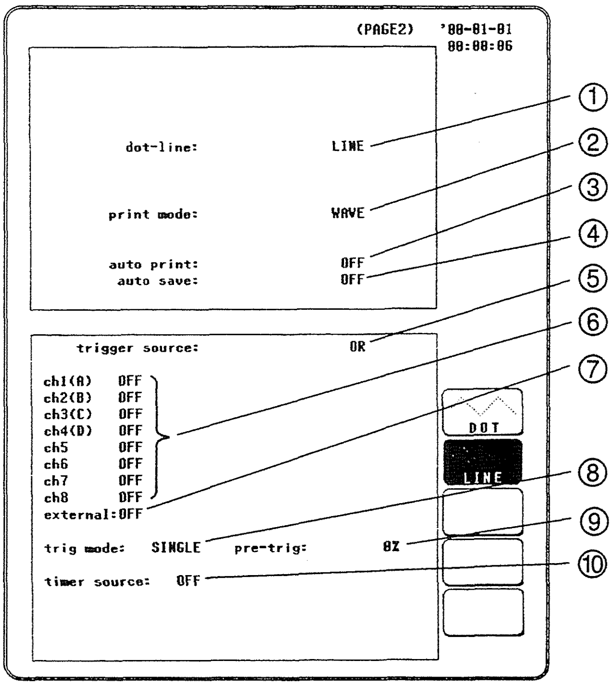


```
***  STATUS  ***    FFT                (PAGE1)   '00-01-01
                                                  00:00:05
            FFT mode:              1CH FFT
      max.frequency:                 40kHz
             window:                RECTAN

             format:                SINGLE
            average:                   OFF

          reference:              NEW DATA


          (mode)          (wl)    (y-axis) (x-axis)
g1:  LINEAR SPECTRUM     CH1      LOG-MAG  LOG-Hz


     (scale)     (lower)        (upper)     (units)
g1:   AUTO    -2.000E+00 ~ +2.000E+00   (V       )
```

STATUS screen (PAGE 1)

① Function
② FFT channel mode
③ Frequency range
④ Window function
⑤ Display format
⑥ Averaging
⑦ Reference data
⑧ FFT analysis mode
⑨ Analysis channel
⑩ Y-axis display
⑪ X-axis display
⑫ Display scale
⑬ Display scale lower limit
⑭ Display scale upper limit
⑮ Display scale units
(display only)

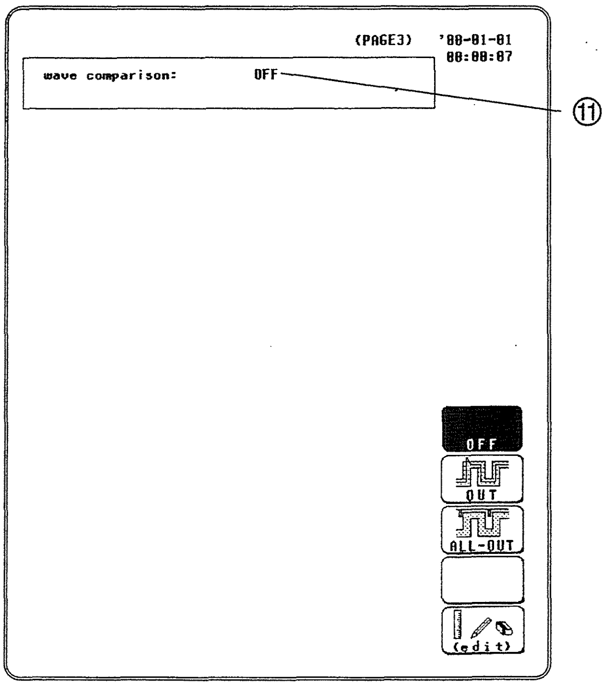
① Function	MEM, REC, XYC, FFT	Sets the function mode.
② FFT channel mode	1CH FFT, 2CH FFT	Sets the number of channels to be analized.
③ Frequency range	133m, 333m, 667m, 2, 4, 8, 20, 40, 80, 200, 400, 800, 2k, 4k, 8k, 20k, 40k, 80kHz	Sets the frequency range.
④ Window function	RECTAN, HANNING, EXPONENTIAL	Sets the window function.
⑤ Display format	SINGLE, DUAL, NYQUIST	Sets the display format.
⑥ Averaging	OFF, T-LIN, T-EXP, F-LIN, F-EXP, F-PEAK	Sets the averaging.
⑦ Reference data	NEW DATA, FROM MEM	Sets the reference data.
⑧ FFT analysis mode	Storage, Linear Spectrum, RMS Spectrum, Power Spectrum, Auto Correlation, Histogram, Transfer, Cross Power, Cross Correlation, Impulse Response, Coherense, Octave	Sets the FFT analysis mode.
⑨ Analysis channel	CH1 to CH8	Sets the analysis channel.
⑩ Y-axis display	LIN-REAL, LIN-IMAG, LIN-MAG, LOG-MAG, PHASE	Sets the Y-axis display.
⑪ X-axis display	LIN-Hz, LOG-Hz 1/1OCT, 1/3OCT (octave analysis mode only)	Sets the X-axis display.
⑫ Display scale	AUTO, MANUAL	Sets the auto or manual scale setting for display.
⑬ Display scale lower limit	-9.999E+29 to +9.999E+29	Sets the lower limit for display scale.
⑭ Display scale upper limit	-9.999E+29 to +9.999E+29	Sets the upper limit for display scale.
⑮ Display scale units (display only)	V, etc.	Displays the selected unit with scaling in the system screen.



```
(PAGE2)  '00-01-01
          00:00:06

dot-line:        LINE

print mode:      WAVE

auto print:      OFF
 auto save:      OFF

trigger source:  OR

ch1(A)    OFF
ch2(B)    OFF
ch3(C)    OFF
ch4(D)    OFF
ch5       OFF
ch6       OFF
ch7       OFF
ch8       OFF
external:OFF

trig mode:  SINGLE   pre-trig:   0%

timer source:  OFF
```

STATUS screen (PAGE 2)

① Interpolation function
② Style for printing
③ Auto print function
④ Auto-save function
⑤ AND/OR for the internal and external triggers
⑥ Internal trigger
⑦ External trigger
⑧ Trigger mode
⑨ Pre-trigger
⑩ Timer trigger



```
(PAGE3)  '00-01-01
          00:00:07
wave comparison:      OFF
```

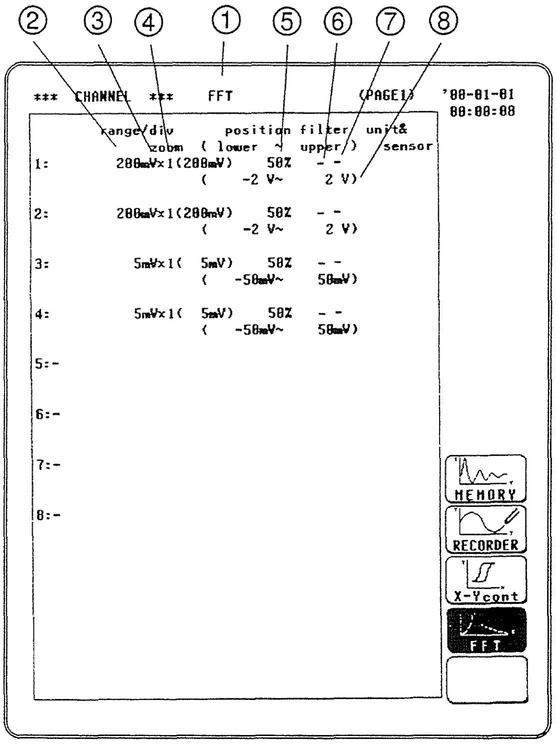
STATUS screen (PAGE 3)

⑪ Waveform decision function (See the Section 11 of the 8840 Manual)

① Interpolation function	DOT, LINE	Sets the interpolation function.
② Style for printing	WAVE, LOGGING	Sets the style for outputting on the printer as a waveform or as numerical values.
③ Auto print function	OFF, ON	Sets whether or not to automatically print out after calculation.
④ Auto-save function	OFF, ON	Sets whether or not to automatically save the file after calculation.
⑤ AND/OR for the internal and external triggers	OR, AND	Triggering occurs if any one of the internal or external trigger conditions holds, or only if all of the triger conditions hold.
⑥ Internal trigger	OFF, LEVEL, IN, OUT, LOGIC	Sets the internal trigger condition.
⑦ External trigger	OFF, ON	Sets whether or not to use an external input as a trigger source.
⑧ Trigger mode	SINGLE, REPEAT, AUTO	Sets the trigger mode.
⑨ Pre-trigger	0, 2, 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, 95, 100, -95%	Sets the pre-trigger
⑩ Timer trigger	OFF, ON	Sets whther or not to use the timer trigger.
⑪ Waveform decision function	OFF, ON	Sets whether or not to perform waveform decision.

3.2 CHANNEL screen

- Press the CHAN key, and the "channel" screen appears.



```
***  CHANNEL  ***    FFT                 (PAGE1)   '00-01-01
                                                    00:00:00
          range/div      position filter  unit&
                 zoom  ( lower  ~  upper  )  sensor
1:        200mV×1(200mV)    50%    - -
                       (     -2 V~      2 V)

2:        200mV×1(200mV)    50%    - -
                       (     -2 V~      2 V)

3:          5mV×1(  5mV)    50%    - -
                       (    -50mV~    50mV)

4:          5mV×1(  5mV)    50%    - -
                       (    -50mV~    50mV)

5:-

6:-

7:-

8:-
```

CHANNEL screen

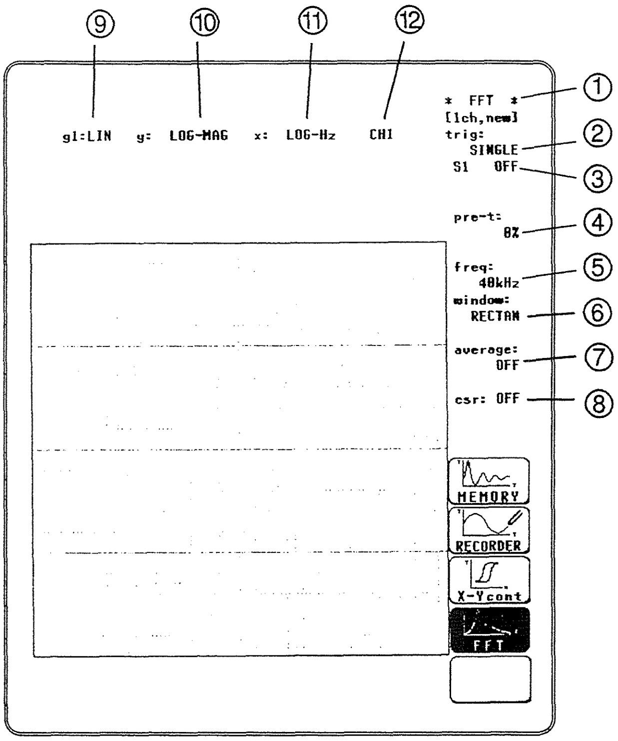
① Function mode
② Voltage axis range
③ Input coupling
④ Voltage axis magnification
⑤ Position
⑥ Low-pass filter
⑦ Anti-aliasing filter
⑧ Upper and lower limit values (display only)

- In the FFT function,it is not possible to change the upper and lower limit values, even if the variable function on the CHANNEL screen(PAGE 2) is set. Set the upper and lower limits in the FFT function in the item of the scale upper and lower limits on the STATUS screen(PAGE 1).

① Function mode	MEM, REC, XYC, FFT	Sets the function.
② Voltage axis range	5m, 10m, 20m, 50m, 100m, 200m, 500m, 1, 2, 5, 10, 20 V	Sets the voltage axis range.
③ Input coupling	DC, GND RMS, RMS-DC (8917 RMS-DC unit only)	Sets input coupling.
④ Voltage axis magnification	X8, X4, X2, X1, X1/2	Sets the voltage axis magnification ratio.
⑤ Position	-28% to 128%	Sets the position for each channel.
⑥ Low-pass filter	OFF, 5kHz, 500Hz, 50Hz, 5Hz (differs depending on the unit)	Sets the low-pass filter.
⑦ Anti-aliasing filter	OFF, ON (8919 FFT analog unit only)	Sets whether or not to use the anti-aliasing filter.
⑧ Upper and lower limit values (display only)		Displays the upper and lower limit values.

3.3 DISPLAY screen

· Press the DISP key, and the DISPLAY screen appears.



gl:LIN y: LOG-MAG x: LOG-Hz CH1

* FFT *
[1ch,new]
trig:
SINGLE
S1 OFF
pre-t:
8%
freq:
48kHz
window:
RECTAN
average:
OFF
csr: OFF

DISPLAY screen

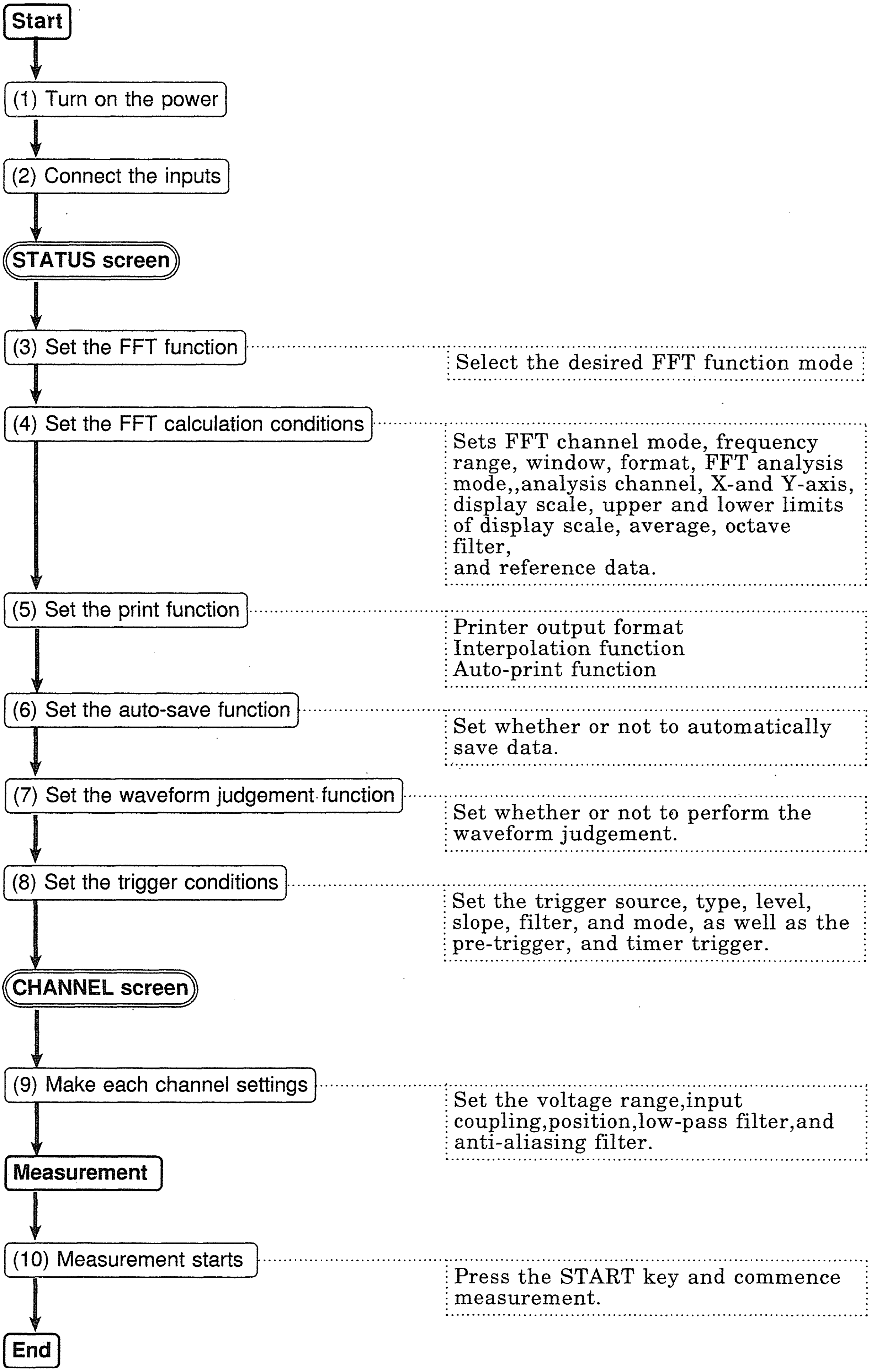
① Function
② Trigger mode
③ Trigger source
④ Pre-trigger
⑤ Frequency range
⑥ Window function
⑦ Averaging
⑧ A/B cursor
⑨ FFT analysis mode
⑩ Y-axis display
⑪ X-axis display
⑫ Analysis channel

① Function	MEM, REC, XYC, FFT	Sets the function.
② Trigger mode	SINGLE, REPEAT, AUTO	Sets the trigger mode.
③ Trigger source	S1 to S8	Sets the trigger source for a channel.
④ Pre-trigger	0, 2, 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, 95, 100, -95%	Sets the pre-trigger.
⑤ Frequency range	133m, 333m, 667m, 2, 4, 8, 20, 40, 80, 200, 400, 800, 2k, 4k, 8k, 20k, 40k, 80kHz	Sets the frequency range.
⑥ Window function	RECTAN, HANNING, EXPONENTIAL	Sets the window function.
⑦ Averaging	OFF, T-LIN, T-EXP, F-LIN, F-EXP, F-PEAK	Sets the averaging.
⑧ A/B cursor	OFF, +	Sets whether display A/B cursor or not.
⑨ FFT analysis mode	STR, LIN, RMS, PSP, ACR, HIS, TRF, CSP, CCR, IMP, COH, OCT	Sets the FFT analysis mode.
⑩ Y-axis display	LIN-REAL, LIN-IMAG, LIN-MAG, LOG-MAG, PHASE	Sets the Y-axis display.
⑪ X-axis display	LIN-Hz, LOG-Hz 1/1OCT, 1/3OCT (when octave analysis mode only)	Sets the X-axis display.
⑫ Analysis channel	CH1 to CH8	Sets the analysis channel.

Chapter 4
Basic Operating Procedures

4.1 Operation flow

· The following flowchart illustrates the basic sequence of operations.



Select the desired FFT function mode

Sets FFT channel mode, frequency range, window, format, FFT analysis mode,,analysis channel, X-and Y-axis, display scale, upper and lower limits of display scale, average, octave filter,
and reference data.

Printer output format
Interpolation function
Auto-print function

Set whether or not to automatically save data.

Set whether or not to perform the waveform judgement.

Set the trigger source, type, level, slope, filter, and mode, as well as the pre-trigger, and timer trigger.

Set the voltage range,input coupling,position,low-pass filter,and anti-aliasing filter.

Press the START key and commence measurement.

4.2 Operation example

This example describes how to connect the 8840 to an oscillator and measure the linear spectrum of a 2 V p-p 1 kHz sine wave input.
(Except for the anti-aliasing filter setting,the following explanation applies equally whether using the 8916 analog unit,8917 DC/RMS unit or the 8919 FFT analog unit.)

(1) Turn on the power

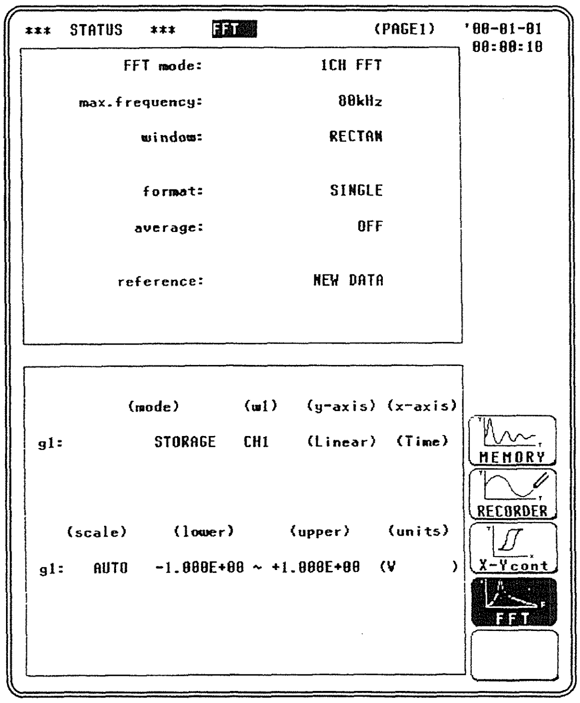
Connect the power cable to the 8840 and turn on the power with the power switch.

(2) Connect the input.

Connect the amplifier to the input terminal of (the 8919 FFT analog unit fitted to) channel 1 of the 8840. Set the amplifier so that the output sine wave has a frequency of 1 kHz and a voltage 2 V p-p.

(3) Set the function mode.

To set the function mode to the FFT function mode:
① Press the STATUS key. The STATUS screen will appear.
② Using the cursor keys, move the flashing cursor to the "function" item.
③ Choose F4 (FFT).



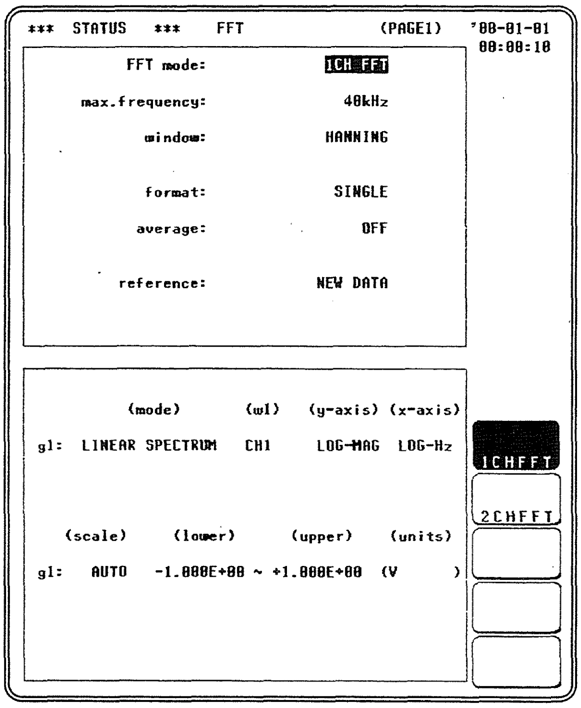
```
***  STATUS  ***   FFT                (PAGE1)   '00-01-01
                                                 00:00:10
              FFT mode:            1CH FFT

        max.frequency:             80kHz

              window:              RECTAN


              format:              SINGLE

             average:              OFF


           reference:              NEW DATA



              (mode)        (wl)   (y-axis) (x-axis)

 g1:              STORAGE    CH1    (Linear)  (Time)



     (scale)     (lower)        (upper)      (units)

 g1:   AUTO    -1.000E+00 ~ +1.000E+00   (V        )
```

STATUS screen (PAGE 1)

(4) Set the FFT calculation conditions.

To set the FFT calculation conditions as shown in the figure below:
Using the cursor keys, move the flashing cursor in turn to each item to be set, and, using `F1` through `F5` select the appropriate values, as explained below.
(For details on the FFT calculation conditions, refer to Section 5. "Making Settings")

FFT channel mode	FFTmode:	1CH FFT
Frequency range	max.frequency:	40kHz
Window function	window:	HANNING
Display format	format:	SINGLE
Averaging	average:	OFF
Reference data	reference:	NEW DATA
FFT analysis mode	(mode)	LINEAR SPECTRUM
Analysis channel	(w1)	CH1
Y-axis display	(y-axis)	LOG-MAG
X-axis display	(x-axis)	LOG-Hz
Display scale	(scale)	AUTO



```
***  STATUS  ***    FFT                    (PAGE1)   '00-01-01
                                                      00:00:10
           FFT mode:              1CH FFT

      max.frequency:                40kHz

             window:              HANNING


             format:               SINGLE

            average:                  OFF


          reference:             NEW DATA



          (mode)          (wl)    (y-axis) (x-axis)

gl:  LINEAR SPECTRUM      CH1      LOG-MAG  LOG-Hz



   (scale)      (lower)         (upper)      (units)

gl:   AUTO    -1.000E+00 ~ +1.000E+00   (V        )
```

STATUS screen (PAGE 1)

(5) Set the print function.

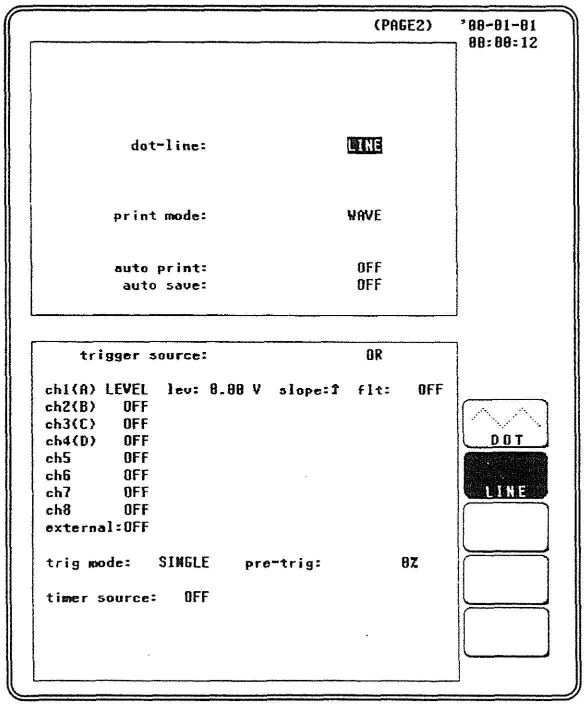
Interpolation function	dot-line:	LINE
Printer output	print mode:	WAVE
Auto-print	auto print:	OFF

(6) Set the auto-save function.

Auto-save function	auto save:	OFF

(7) Set the trigger conditions.

Trigger source	trigger sourse:	OR
	ch1(A)	LEVEL lev:0.00V slope:↑ flt:OFF
	ch2(B)	OFF
	ch3(C)	OFF
	ch4(D)	OFF
	ch5	OFF
	ch6	OFF
	ch7	OFF
	ch8	OFF
External trigger	external:	OFF
Trigger mode	trig mode:	SINGLE
Pre-trigger	pre-trig:	0%
Timer trigger	timer sourse:	OFF

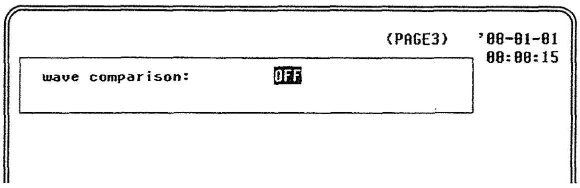


```
                                          (PAGE2)   '00-01-01
                                                     00:00:12

          dot-line:                     LINE

        print mode:                     WAVE

        auto print:                      OFF
         auto save:                      OFF

     trigger source:                     OR

ch1(A) LEVEL  lev: 0.00 V  slope:↑  flt:   OFF
ch2(B)   OFF
ch3(C)   OFF
ch4(D)   OFF
ch5      OFF
ch6      OFF
ch7      OFF
ch8      OFF
external:OFF

trig mode:   SINGLE    pre-trig:        0%

timer source:   OFF
```

STATUS screen (PAGE 2)

(8)Set the waveform decision function.

Waveform judgment function	wave comparison:	OFF



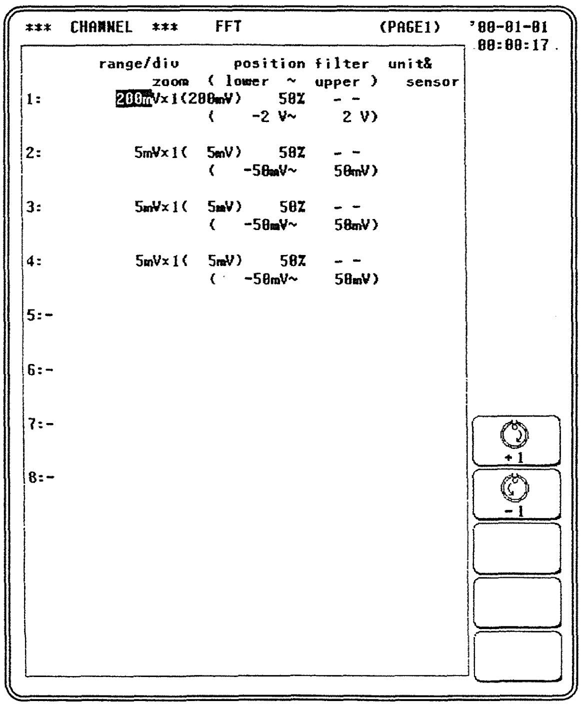
```
                                  (PAGE3)   '00-01-01
                                             00:00:15
  wave comparison:          OFF
```

STATUS screen (PAGE 3)

(9)Make the settings for each channel.

Press the channel key, and the CHANNEL screen will appear.
Using the cursor keys, move the flashing cursor to the setting item, and set by using the F1 to F5 .

Voltage axis range setting	range/div	ch1: 200m
Input coupling setting		V (DC)
Voltage axis magnification/ compression ratio setting		x1
Origin position setting	position	50%
Low pass filter setting	filter	-(off)
Anti-aliasing filter setting	aaf	-(off)

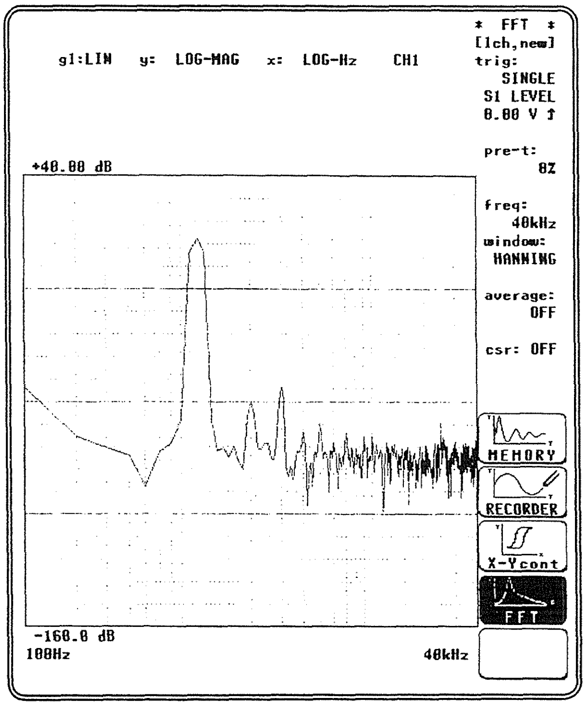


```
***  CHANNEL  ***     FFT              (PAGE1)   '00-01-01
                                                  00:00:17
          range/div      position filter  unit&
                 zoom  ( lower  ~  upper )   sensor
1:          200mVx1(200mV)     50%    - -
                       (    -2 V~     2 V)

2:             5mVx1(  5mV)    50%    - -
                       (   -50mV~    50mV)

3:             5mVx1(  5mV)    50%    - -
                       (   -50mV~    50mV)

4:             5mVx1(  5mV)    50%    - -
                       (   -50mV~    50mV)

5:-

6:-

7:-

8:-
```

CHANNEL screen (PAGE 1)

(10) Begin measurement

Press the START key. The LED above the key lights up. Since input is already present, triggering occurs immediately and 1000 points of data are captured. When capture is completed, FFT calculations are performed. The FFT calculation is completed, the LED goes out, the system enters the STOP condition, then the waveform is displayed on the screen.



g1:LIN y: LOG-MAG x: LOG-Hz CH1

* FFT *
[1ch,new]
trig:
SINGLE
S1 LEVEL
0.00 V ↑
pre-t:
0%
freq:
40kHz
window:
HANNING
average:
OFF
csr: OFF

DISPLAY screen

ple

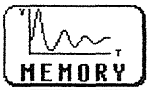
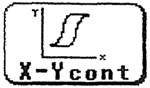
Chapter 5
Making Settings

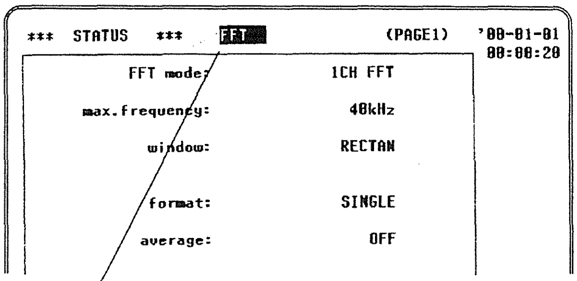
5.1 Setting the FFT Function Mode

- The 8840 has four function modes; the memory recorder function mode, the recorder function mode, the X-Y recorder function mode and the FFT function mode. Select the FFT function mode for performing FFT analysis.

Method (Screens for making this setting: the STATUS, CHANNEL, and DISPLAY screens)

1. Using the cursor keys, move the flashing cursor to the position shown in the figure below.
2. Select F4 (FFT), according to the indications on the function keys.

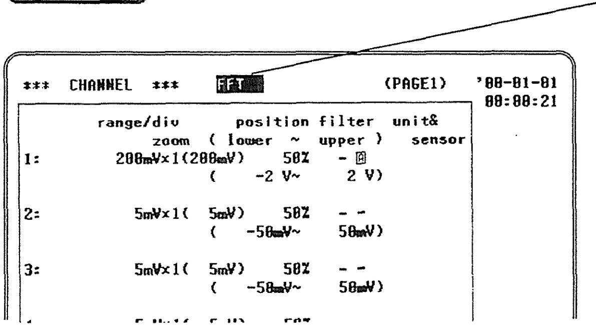
Function key indication	*Meaning*
 MEMORY	: Memory recorder function mode
 RECORDER	: Recorder function mode
 X-Ycont	: X-Y recorder function mode
 FFT	: FFT function mode



```
***  STATUS  ***   FFT                 (PAGE1)   '00-01-01
                                                  00:00:20
            FFT mode:              1CH FFT
      max.frequency:                  40kHz
             window:                 RECTAN

             format:                 SINGLE
            average:                    OFF
```

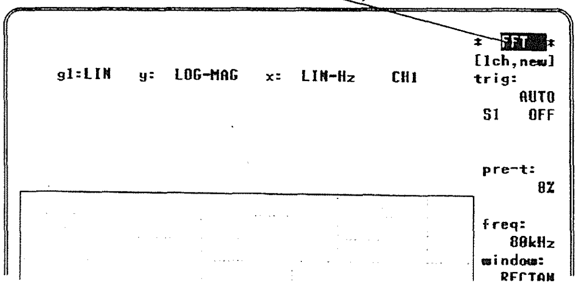
STATUS screen

Flashing cursor



```
***  CHANNEL  ***   FFT              (PAGE1)   '00-01-01
                                                00:00:21
      range/div       position filter  unit&
            zoom  ( lower  ~  upper )   sensor
1:       200mV×1(200mV)     50%    - A
                  (    -2 V~      2 V)

2:          5mV×1(  5mV)    50%    - -
                  (   -50mV~     50mV)

3:          5mV×1(  5mV)    50%    - -
                  (   -50mV~     50mV)
```

CHANNEL screen



```
                                                  *  FFT  *
                                                  [1ch,new]
   g1:LIN   y:  LOG-MAG   x:  LIN-Hz   CH1        trig:
                                                       AUTO
                                                   S1   OFF


                                                   pre-t:
                                                         0%

                                                   freq:
                                                      80kHz
                                                  window:
                                                     RECTAN
```

DISPLAY screen

5.2 Setting the FFT Channel Mode

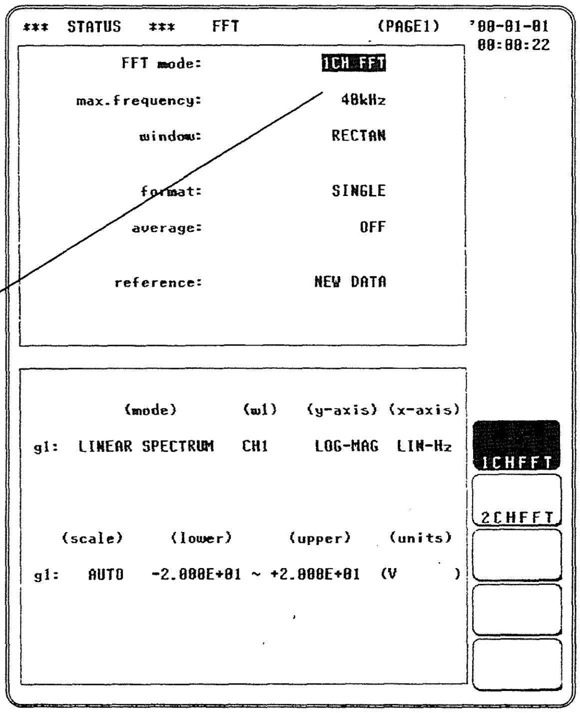
- Select either the 1CH FFT mode or the 2CH FFT mode.
- FFT analysis modes available differ according to which channel mode you select.

Method (Screens for making this setting: the STATUS and DISPLAY screens)

1. Using the cursor keys, move the flashing cursor to the "FFT mode" item or the position shown in the figure on the right.
2. Select the FFT mode according to the indications on the function keys.

Function key indication	*Meaning*
1CHFFT	: Used for FFT analysis of signals from one channel.
2CHFFT	: Used for simultaneous FFT analysis of two channels.

Flashing cursor



```
***  STATUS   ***    FFT                 (PAGE1)   '00-01-01
                                                   00:00:22
          FFT mode:              1CH FFT
     max.frequency:                 40kHz
           window:                 RECTAN

           format:                 SINGLE
          average:                    OFF

        reference:               NEW DATA

          (mode)          (wl)   (y-axis) (x-axis)
g1:  LINEAR SPECTRUM      CH1     LOG-MAG  LIN-Hz

   (scale)     (lower)        (upper)     (units)
g1:   AUTO    -2.000E+01 ~ +2.000E+01   (V       )
```

STATUS screen

FFT analysis mode		1CHFFT	2CHFFT
Time-axis waveform	STR	Yes	Yes
Linear spectrum	LIN	Yes	Yes
RMS spectrum	RMS	Yes	Yes
Power spectrum	PSP	Yes	Yes
Auto correlation	ACR	Yes	Yes
Histogram	HIS	Yes	Yes
Transfer function	TRF	No	Yes
Cross power	CSP	No	Yes
Cross correlation	CCR	No	Yes
Impulse response	IMP	No	Yes
Coherence function	COH	No	Yes
Octave analysis	OCT	Yes	Yes

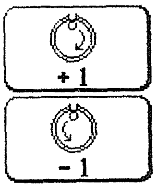
5.3 Setting the Frequency Range

- Set FFT for the frequency range of the input signal waveform to be captured.
- The frequency range corresponds to the time base range (TIME/DIV) of the Memory recorder function.

Method (Screens for making this setting: the STATUS and DISPLAY screens)

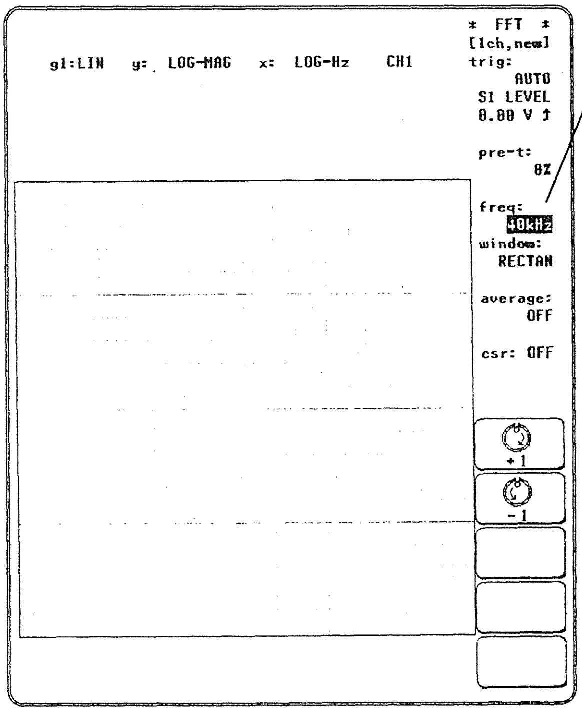
1. Using the cursor key, move the flashing cursor to the "max. frequency" item on the STATUS screen or "freq" on the DISPLAY screen.
2. Using the function keys or the rotary knob, set the frequency range.

Function key indication *Meaning*



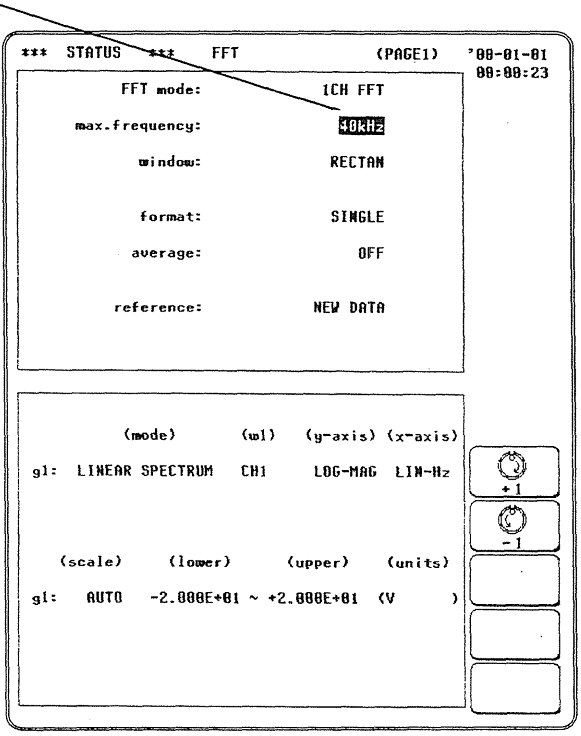
133, 333, 667 mHz
2, 4, 8, 20, 40, 80, 200, 400, 800 Hz
2, 4, 8, 20, 40, 80 kHz

Flashing cursor



```
gl:LIN   y: LOG-MAG   x: LOG-Hz   CH1      * FFT *
                                           [lch,new]
                                           trig:
                                               AUTO
                                            S1 LEVEL
                                            0.00 V ↑

                                            pre-t:
                                                 0%

                                            freq:
                                              40kHz
                                            window:
                                              RECTAN

                                            average:
                                                OFF

                                            csr: OFF
```

DISPLAY screen



```
***  STATUS  ***   FFT              (PAGE1)   '00-01-01
                                               00:00:23
          FFT mode:            1CH FFT

     max.frequency:              40kHz

            window:             RECTAN

            format:             SINGLE

           average:                OFF

         reference:           NEW DATA


           (mode)         (wl)    (y-axis) (x-axis)
gl:  LINEAR SPECTRUM      CH1     LOG-MAG  LIN-Hz


   (scale)     (lower)        (upper)     (units)
gl:   AUTO   -2.000E+01 ~ +2.000E+01  (V        )
```

STATUS screen

- Time base, window width, and frequency resolution corresponding to each frequency range.

Frequency range	TIME/DIV	Window width	Frequency resolution
80 kHz #	500 μs/DIV	5 ms	200 Hz
40 kHz	1 ms/DIV	10 ms	100 Hz
20 kHz	2 ms/DIV	20 ms	50 Hz
8 kHz	5 ms/DIV	50 ms	20 Hz
4 kHz	10 ms/DIV	100 ms	10 Hz
2 kHz	20 ms/DIV	200 ms	5 Hz
800 Hz	50 ms/DIV	500 ms	2 Hz
400 Hz	100 ms/DIV	1 s	1 Hz
200 Hz	200 ms/DIV	2 s	500 mHz
80 Hz	500 ms/DIV	5 s	200 mHz
40 Hz	1 s/DIV	10 s	100 mHz
20 Hz	2 s/DIV	20 s	50 mHz
8 Hz *	5 s/DIV	50 s	20 mHz
4 Hz *	10 s/DIV	100 s	10 mHz
2 Hz *	20 s/DIV	200 s	5 mHz
667 mHz *	1 min/DIV	600 s	1.67 mHz
333 mHz *	2 min/DIV	1200 s	0.83 mHz
133 mHz *	5 min/DIV	3000 s	0.33 mHz

Note With the 8919 FFT analog unit, the anti-aliasing filter's cutoff frequency is the same as the frequency range.
(#; Anti-aliasing is OFF with the 80 kHz range.)
(*; The cutoff frequency is 20 Hz.)

5.4 Setting the Window Function

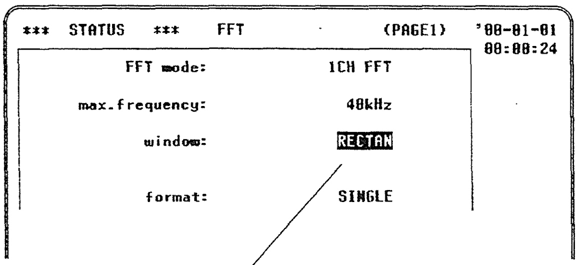
- The window function defines the segment of the input signal that will be processed.
- Window processing can be used to minimize leakage error.

Method (Screens for making this setting: the STATUS and DISPLAY screens)

1. Using the cursor keys, move the flashing cursor to the "window" item.
2. Select the window function according to the indications on the function keys.

Function key indication	*Meaning*
	: Rectangular function
	: Hanning function
	: Exponential window function)

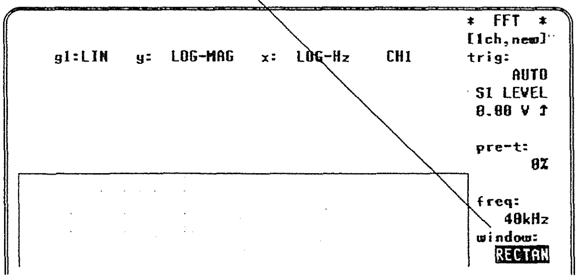
RECTAN	effective on discrete waveforms.
HANNING	effective on continuous waveforms.
EXPO	effective on decaying waveforms.



```
*** STATUS ***  FFT        (PAGE1)  '00-01-01
                                     00:00:24
        FFT mode:          1CH FFT
  max.frequency:           40kHz
         window:           RECTAN

         format:           SINGLE
```

STATUS screen

Flashing cursor

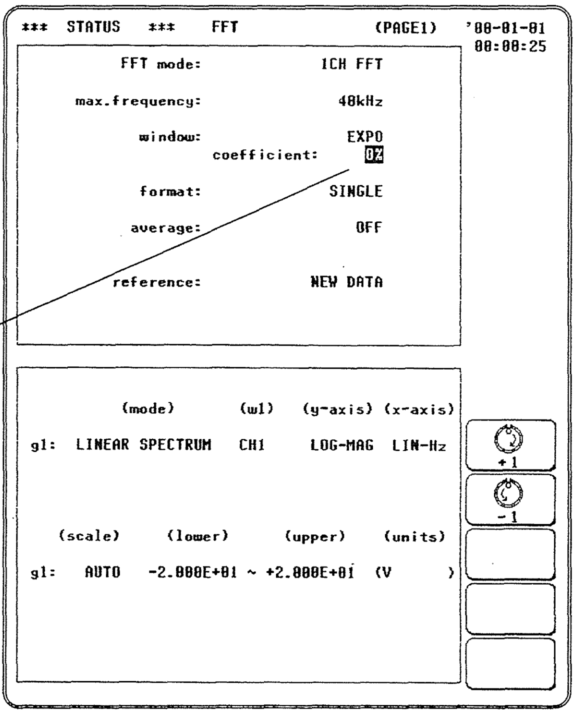


```
                                          * FFT *
                                          [1ch,new]
g1:LIN   y: LOG-MAG   x: LOG-Hz    CH1    trig:
                                             AUTO
                                          SI LEVEL
                                          0.00 V ↑

                                          pre-t:
                                               0%

                                          freq:
                                            40kHz
                                          window:
                                           RECTAN
```

DISPLAY screen

3. When F3 (EXPO) is selected in step 2 above, you can use the function key indication to set the attenuation percentage in the coefficient parameter.

Function key indication	*Meaning*
+1 -1	Settings possible in 1% increments over the range from 0 to 99%.

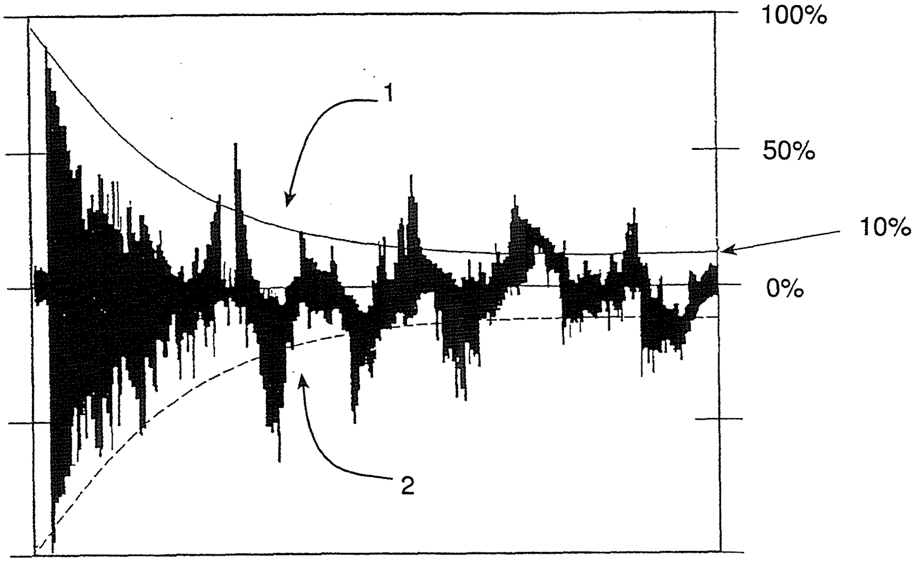


```
***  STATUS  ***   FFT                 (PAGE1)  '00-01-01
                                                 00:00:25
              FFT mode:              1CH FFT

        max.frequency:                 40kHz

               window:                  EXPO
                       coefficient:       0%

               format:                SINGLE

              average:                   OFF


            reference:              NEW DATA


          (mode)        (wl)   (y-axis) (x-axis)
 gl:  LINEAR SPECTRUM   CH1     LOG-MAG  LIN-Hz



     (scale)     (lower)       (upper)     (units)
 gl:   AUTO   -2.000E+01 ~ +2.000E+01  (V       )
```

Flashing cursor

STATUS screen

Example When the attenuation ratio is set to 10%

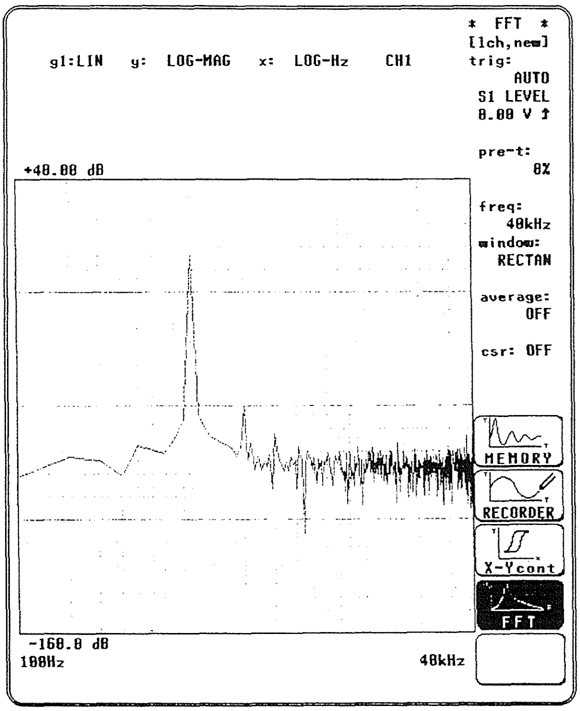


- In the figure above, the attenuation ratio is set over the range 0-99%.
- The actual window has the form of two curves, 1 and 2.
- 0.1% is used for calculation if 0% is set.

Note When measurements are taken using the Hanning window or exponential window, note that the calculation results in the display of a value that is lower than the amplitude obtained when using a rectangular window.

5.5 Setting the Display Format

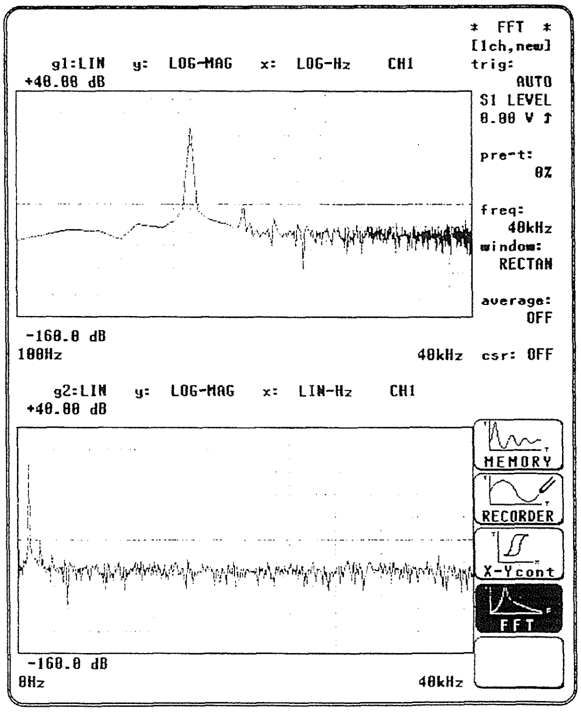
- You can set the format for displaying input signal waveforms on the screen and recording them on the printer.
- The SINGLE, DUAL, NYQUIST, and ARRAY formats are available.



* FFT *
[1ch,new]
g1:LIN y: LOG-MAG x: LOG-Hz CH1
trig: AUTO
S1 LEVEL 0.00 V ↑
pre-t: 0%
freq: 40kHz
window: RECTAN
average: OFF
csr: OFF

① SINGLE

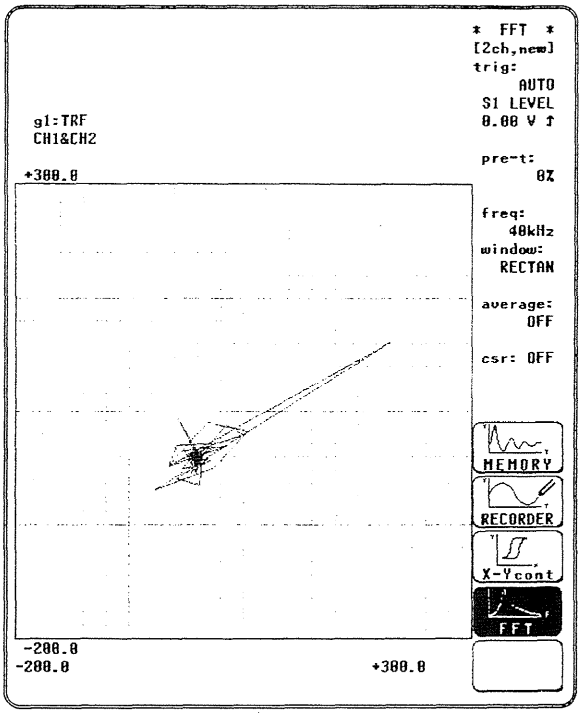
Displays the waveform on a single screen.



* FFT *
[1ch,new]
g1:LIN y: LOG-MAG x: LOG-Hz CH1
trig: AUTO
S1 LEVEL 0.00 V ↑
pre-t: 0%
freq: 40kHz
window: RECTAN
average: OFF
csr: OFF
g2:LIN y: LOG-MAG x: LIN-Hz CH1

② DUAL

Divides the waveform display screen into upper and lower screens. Multiple results can be displayed individually.



```
* FFT *
[2ch,new]
trig:
      AUTO
S1 LEVEL
0.00 V ↑
pre-t:
        0%
freq:
     40kHz
window:
    RECTAN
average:
       OFF
csr: OFF
```

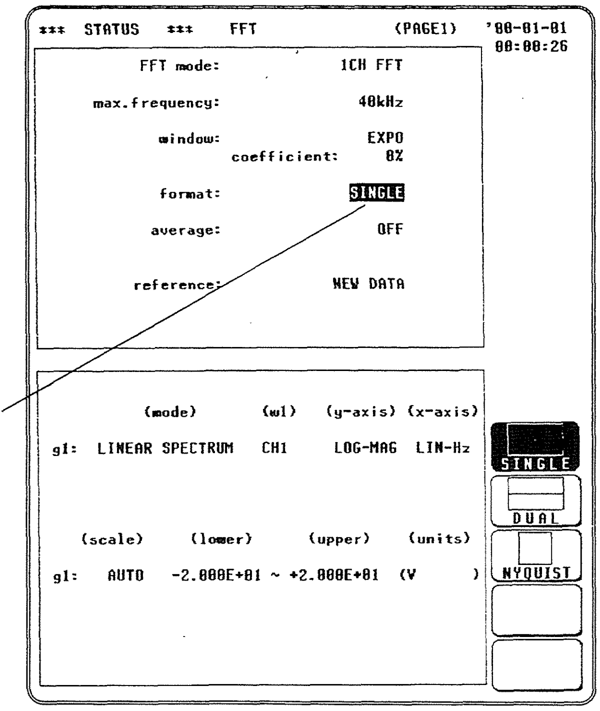
③ NYQUIST

For the linear spectrum, cross power spectrum, and transfer function, displays the real-number portion of the data for the FFT calculation result on the X-axis, and the imaginarynumber portion of the data on the Y-axis.

Method (Screen for making this setting: the STATUS screen)

1. Using the cursor keys, move the flashing cursor to the "format" item.
2. Select the desired format according to the indications on the function keys.

Function key indication	*Meaning*
SINGLE	: SINGLE
DUAL	: DUAL
NYQUIST	: NYQUIST



```
***  STATUS  ***   FFT                  (PAGE1)   '00-01-01
                                                    00:00:26
              FFT mode:             1CH FFT

         max.frequency:               40kHz

               window:                 EXPO
                        coefficient:     0%

               format:               SINGLE

              average:                  OFF

            reference:             NEW DATA


            (mode)          (wl)   (y-axis) (x-axis)
g1:  LINEAR SPECTRUM        CH1     LOG-MAG   LIN-Hz


     (scale)     (lower)        (upper)      (units)
g1:   AUTO    -2.000E+01 ~ +2.000E+01   (V          )
```

Flashing cursor

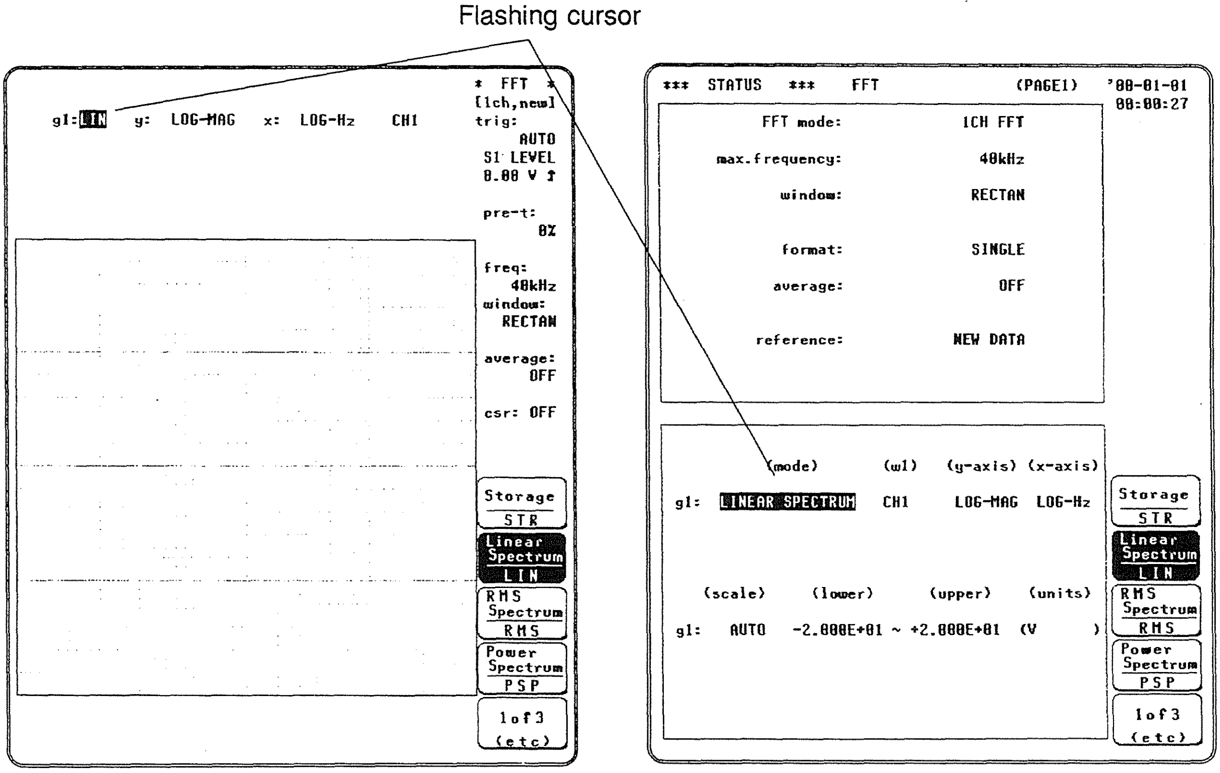
STATUS screen

5.6 Setting the FFT Analysis Mode

- Used to select the FFT calculation method.

Method (Screen for making this setting: the STATUS and DISPLAY screens)

1. Using the cursor keys, move the flashing cursor to the "mode" item.
2. Select the desired calculation mode according to the indications on the function keys.
   - When 1CH FFT is selected, the following five analysis functions cannot be used: transfer function, cross-power spectrum, cross-correlation function, impulse response, and coherence function.



```
g1:LIN   y: LOG-MAG   x: LOG-Hz   CH1        * FFT *
                                             [1ch,new]
                                             trig:
                                                  AUTO
                                             S1 LEVEL
                                             0.00 V ↑

                                             pre-t:
                                                    0%

                                             freq:
                                                 40kHz
                                             window:
                                                RECTAN

                                             average:
                                                   OFF

                                             csr: OFF
```

DISPLAY screen

```
***  STATUS  ***   FFT                 (PAGE1)   '00-01-01
                                                  00:00:27
            FFT mode:               1CH FFT

      max.frequency:                 40kHz

             window:                RECTAN


             format:                SINGLE

            average:                   OFF


          reference:              NEW DATA


            (mode)          (wl)   (y-axis) (x-axis)

g1:  LINEAR SPECTRUM        CH1     LOG-MAG  LOG-Hz


   (scale)    (lower)       (upper)       (units)

g1:  AUTO   -2.000E+01 ~ +2.000E+01   (V         )
```

STATUS screen

● 1 of 3

Function key indication	*Meaning*
Storage STR	: Stored waveform (Section 2.1)
Linear Spectrum LIN	: Linear spectrum (Section 2.2)
RMS Spectrum RMS	: RMS spectrum (Section 2.3)
Power Spectrum PSP	: Power spectrum (Section 2.4)
1of3 (etc)	: Displays 2 of 3

● 2 of 3

Function key indication	*Meaning*
Auto Correlation ACR	: Auto correlation function (Section 2.5)
Histogram HIS	: Histogram (Section 2.6)
Transfer TRF	: Transfer function (Section 2.7)
Cross Power CSP	: Cross power spectrum (Section 2.8)
2of3 (etc)	: Displays 3 of 3

● 3 of 3

Function key indication	*Meaning*
Cross Correlation CCR	: Cross correlation function (Section 2.9)
Impulse Response IMP	: Impulse response (Section 2.10)
Coherense COH	: Coherence function (Section 2.11)
Octave OCT	: Octave analysis (Section 2.12)
3of3 (etc)	: Displays 1 of 3

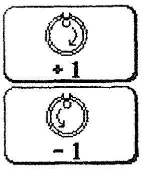
5.7 Setting the Analysis Channel

Select the channel for FFT analysis.

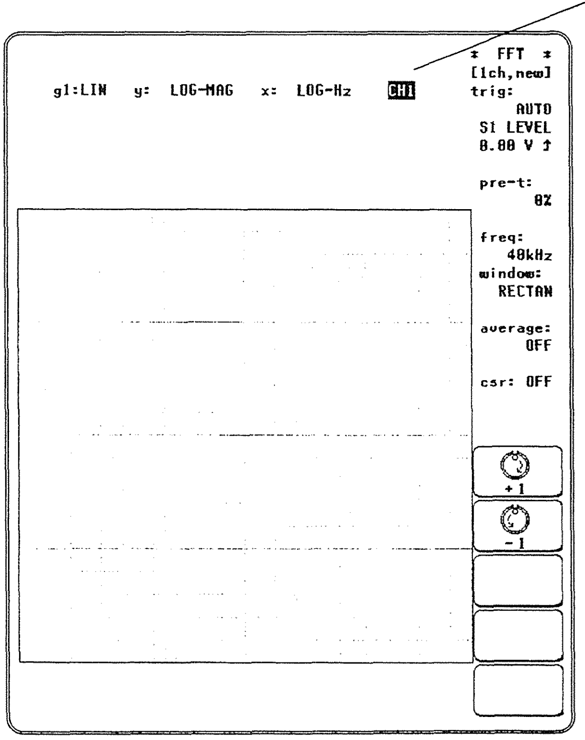
Method (Screen for making this setting: the STATUS and DISPLAY screens)

1. Using the cursor keys, move the flashing cursor to the "w1" item.
2. Using the function keys or the rotary knob, select the channel.
3. When choosing CH2 in the FFT, "w2" can be selected.

Note For the transfer function and impulse response, calculation is performed from "(w2)/(w1)".

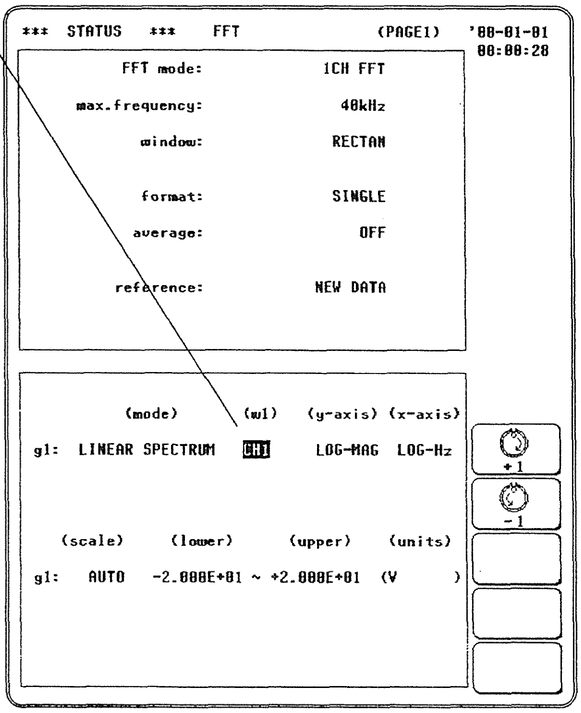
Function key indication	*Meaning*
	: CH1 to CH8

Flashing cursor



```
g1:LIN  y:  LOG-MAG  x:  LOG-Hz  CH1        * FFT *
                                            [1ch,new]
                                            trig:
                                                 AUTO
                                             S1 LEVEL
                                             0.00 V ↑
                                            pre-t:
                                                   0%
                                            freq:
                                                40kHz
                                            window:
                                               RECTAN
                                            average:
                                                  OFF
                                            csr: OFF
```

DISPLAY screen



```
***  STATUS  ***     FFT              (PAGE1)   '00-01-01
                                                 00:00:28
            FFT mode:               1CH FFT
      max.frequency:                  40kHz
             window:                 RECTAN

             format:                 SINGLE
            average:                    OFF

          reference:               NEW DATA

           (mode)       (w1)    (y-axis)  (x-axis)
 g1:  LINEAR SPECTRUM   CH1     LOG-MAG   LOG-Hz

    (scale)     (lower)        (upper)     (units)
 g1:  AUTO   -2.000E+01 ~ +2.000E+01   (V        )
```

STATUS screen

5.8 Setting the X-axis and Y-axis Displays

- Set the X and Y axis for display of FFT calculation results.
- Different units can be selected for the X and Y axis.
- With some FFT analysis modes, one of the axis cannot be set.

Method (Screens for making this setting: the STATUS and DISPLAY screens)

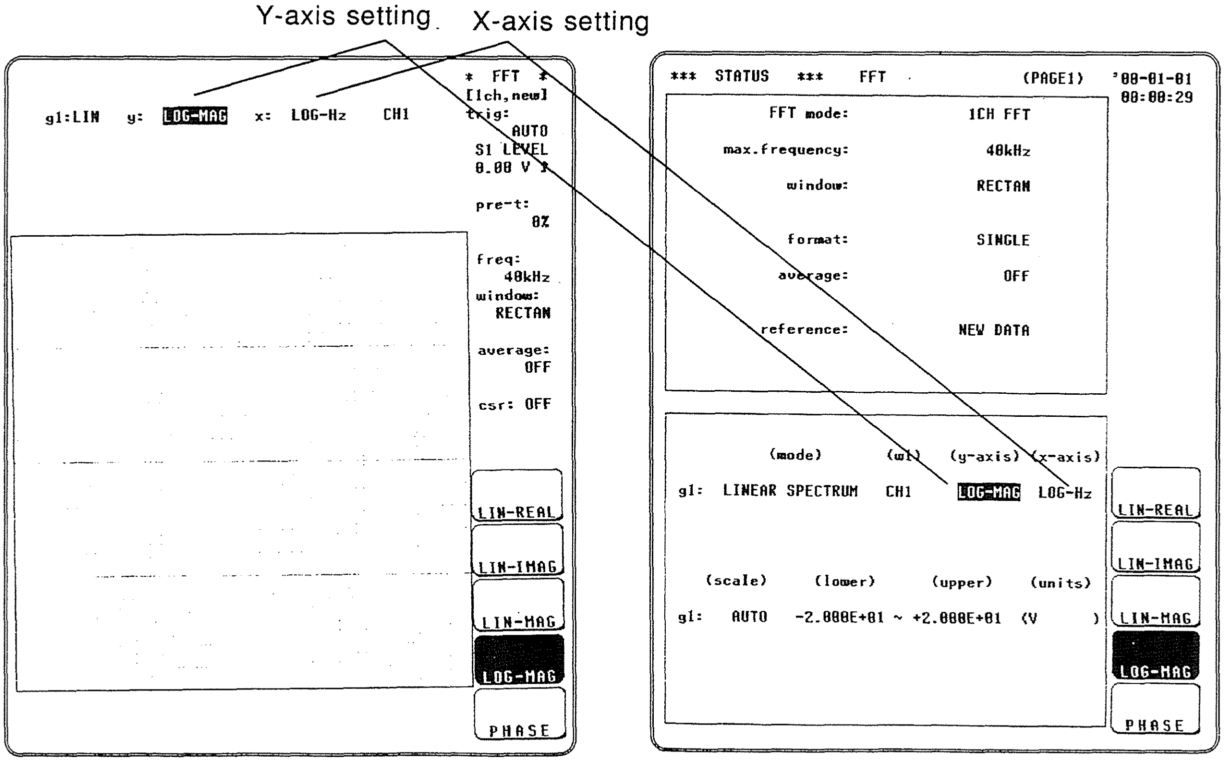
1. Using the cursor keys, move the flashing cursor to the "x-axis" item.
2. Using the function key, set the units of the X-axis.
3. Set the y-axis units in the same manner for the X axis.

● X-axis setting

Function key indication	*Meaning*
LIN-MAG	: Linear. Hz
LOG-MAG	: Log. Hz
1/3 OCT	: 1/3 OCT
1/1 OCT	: 1/1 OCT (Octave mode)

● Y-axis setting

Function key indication	*Meaning*
LIN-REAL	: Linear. Real
LIN-IMAG	: Linear. Imag
LIN-MAG	: Linear. Mag
LOG-MAG	: Log. Mag
PHASE	: Phase



```
gl:LIN   y: LOG-MAG   x: LOG-Hz   CH1

* FFT *
[1ch,new]
trig:
   AUTO
S1 LEVEL
0.00 V

pre-t:
      0%

freq:
   40kHz
window:
  RECTAN

average:
     OFF

csr: OFF
```

DISPLAY screen

```
***  STATUS  ***   FFT              (PAGE1)   '00-01-01
                                               00:00:29
             FFT mode:           1CH FFT

        max.frequency:             40kHz

              window:            RECTAN


              format:            SINGLE

             average:               OFF


           reference:          NEW DATA


          (mode)          (wl)   (y-axis) (x-axis)

gl:  LINEAR SPECTRUM    CH1      LOG-MAG  LOG-Hz


  (scale)     (lower)        (upper)     (units)

gl:   AUTO   -2.000E+01 ~ +2.000E+01   (V        )
```

STATUS screen

- X and Y axis settings available with each FFT analysis mode

FFT analysis mode	Y-axis (vertical axis)	X-axis (horizontal axis)
[STR] Storage waveform	(LIN-MAG)	(TIME)
[LIN] Linear spectrum	LIN-REAL LIN-IMAG LIN-MAG LOG-MAG PHASE	LIN-Hz LOG-Hz
[RMS] RMS spectrum	LIN-REAL LIN-IMAG LIN-MAG LOG-MAG PHASE	LIN-Hz LOG-Hz
[PSP] Power spectrum	LIN-MAG LOG-MAG	LIN-Hz LOG-Hz
[ACR] Auto correlation function	(LIN-MAG)	(TIME)
[HIS] Histogram	(LIN-MAG)	(VOLT)
[TRF] Transfer function	LIN-REAL LIN-IMAG LIN-MAG LOG-MAG PHASE	LIN-Hz LOG-Hz
[CSP] Cross power spectrum	LIN-REAL LIN-IMAG LIN-MAG LOG-MAG PHASE	LIN-Hz LOG-Hz
[CCR] Cross correlation function	(LIN-MAG)	(TIME)
[IMP] Unit impulse response	(LIN-MAG)	(TIME)
[COH] Coherence function	(LIN-MAG)	LIN-Hz LOG-Hz
[OCT] Octave analysis	LIN-MAG LOG-MAG	1/3 OCT 1/1 OCT

5.9 Setting the Display Scale

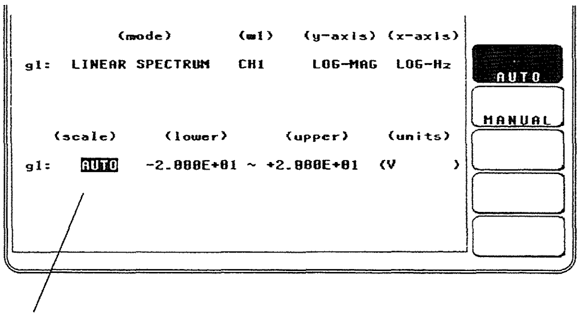
(1) Setting the Display Scale

- Select the AUTO or MANUAL scale setting for displaying FFT calculation results.
- If you select AUTO, the scale is set automatically.
- If you select MANUAL, you can set whatever vertical scale best suits your purpose. The ability to enlarge or reduce the amplitude and to shift the waveform up and down is useful for observing and analyzing waveforms.

Method (Screen for making this setting: the STATUS screen)

- Using the cursor keys, move the flashing cursor to the position shown in the figure below.

Function key indication	*Meaning*
AUTO	: Scale set automatically.
MANUAL	: Scale set manually.



```
        (mode)          (ml)   (y-axis) (x-axis)
g1:  LINEAR SPECTRUM    CH1      LOG-MAG  LOG-Hz

   (scale)      (lower)        (upper)     (units)
g1:   AUTO    -2.000E+01 ~ +2.000E+01   (V       )
```

Flashing cursor

STATUS screen

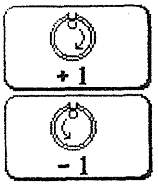
When F1 (AUTO) is selected, the upper and lower limits are determined automatically from the calculation results after the calculation is completed.

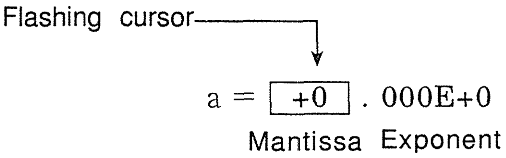
(2) Setting the display scale's upper and lower limits (with MANUAL setting only)

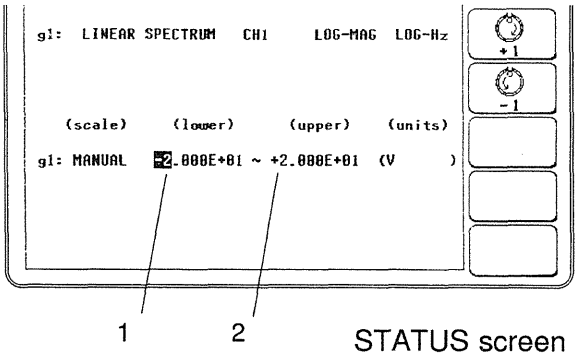
- Set the upper and lower limits for display and recording of calculation results.
- Limits can be set anywhere in the range from -9.999E+29 to +9.999E+29.

Method (Screen for making this setting: the STATUS screen)

1. Move the flashing cursor to the "lower" item, 1.
2. Move the flashing cursor to each individual digit and set the lower limit using the function keys or the rotary knob.
3. Move the flashing cursor to the "upper" item, 2, and set the upper limit in the same manner.

Function key indication	*Meaning*
	0 to 9 (-9 to +9 for the most significant digit and exponent.)





```
g1:  LINEAR SPECTRUM   CH1      LOG-MAG  LOG-Hz

  (scale)      (lower)       (upper)     (units)
g1: MANUAL   -2.000E+01 ~ +2.000E+01  (V      )
```

STATUS screen

(3) Displaying the display scale units

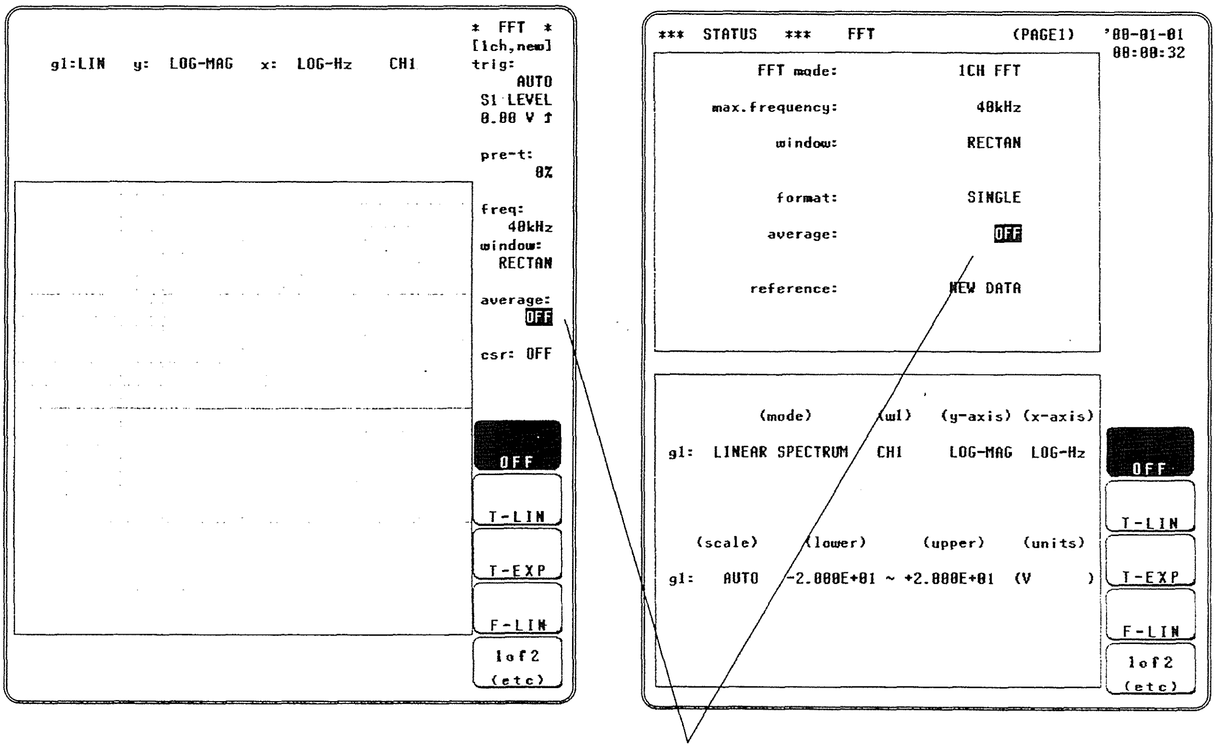
- The selected unit is displayed with "scaling" in the system screen.
- When scaling is turned OFF, V (volts) is displayed.

5.10 Setting Averaging

- With periodic waveform signals, averaging is effective for isolating the significant signal when the input signal contains much random noise. It is also useful for increasing the reliability of unstable phenomena.
- With the 8840, a variety of types of averaging can be performed, both on the time axis and the frequency axis. A peak hold function is also provided for the frequency axis. (Averaging can not be used on both the time axis and the frequency axis simultaneously.)
- Set the axis to be averaged and the number of repetitions to be used in averaging.

Method (Screens for making this setting: the STATUS and DISPLAY screens)

1. Using the cursor keys, move the flashing cursor to the "average" item.
2. Select the desired type of averaging according to the indications on the function keys.



```
g1:LIN  y: LOG-MAG  x: LOG-Hz   CH1        * FFT *
                                           [1ch,new]
                                           trig:
                                                AUTO
                                           S1 LEVEL
                                           0.00 V ↑

                                           pre-t:
                                                  0%

                                           freq:
                                              40kHz
                                           window:
                                             RECTAN

                                           average:
                                                 OFF

                                           csr: OFF
```

```
***  STATUS  ***     FFT               (PAGE1)   '00-01-01
                                                  00:00:32
          FFT mode:                 1CH FFT

    max.frequency:                  40kHz

           window:                  RECTAN

           format:                  SINGLE

          average:                  OFF

        reference:                  NEW DATA


         (mode)            (wl)   (y-axis)  (x-axis)
g1:  LINEAR SPECTRUM       CH1    LOG-MAG   LOG-Hz


   (scale)     (lower)        (upper)       (units)
g1:  AUTO    -2.000E+01  ~  +2.000E+01    (V      )
```

DISPLAY screen Flashing cursor STATUS screen

Note After averaging operation, it is not possible to change the external unit name and offset value.

● 1 of 2

Function key indication	*Meaning*
OFF	: OFF
T-LIN	: Simple averaging against time axis
T-EXP	: Exponential averaging against time axis
F-LIN	: Simple averaging against frequency axis.
1of2 (etc)	: Display 2 of 2

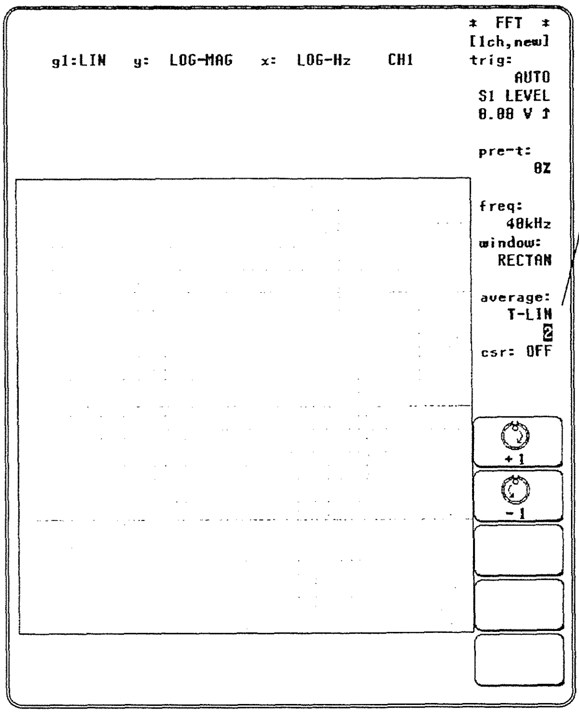
● 2 of 2

Function key indication	*Meaning*
F-EXP	: Exponential averaging against frequency axis
F-PEAK	: Peak hold against frequency axis
2of2 (etc)	: Display 1 of 2

3. After making a selection in step 2, move to the "number" items.
4. Using the function keys or the rotary knob, set the number of times for averaging.

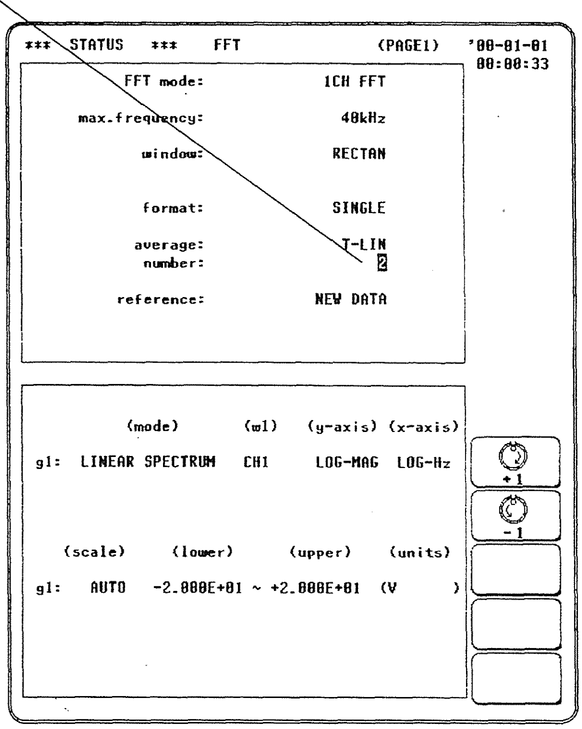
Function key indication	*Meaning*
+1 -1	2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048, 4096

Flashing cursor



```
                                           * FFT  *
                                           [1ch,new]
 g1:LIN   y:  LOG-MAG   x:  LOG-Hz   CH1   trig:
                                                AUTO
                                            S1 LEVEL
                                            0.00 V ↑

                                           pre-t:
                                                  0%

                                           freq:
                                               40kHz
                                           window:
                                              RECTAN

                                           average:
                                               T-LIN
                                                   2
                                           csr: OFF
```

DISPLAY screen



```
*** STATUS  ***    FFT              (PAGE1)   '00-01-01
                                               00:00:33
              FFT mode:          1CH FFT

        max.frequency:             40kHz

               window:            RECTAN


               format:            SINGLE

              average:             T-LIN
               number:                 2

            reference:          NEW DATA



          (mode)        (wl)   (y-axis) (x-axis)

 g1:  LINEAR SPECTRUM   CH1     LOG-MAG  LOG-Hz



    (scale)     (lower)       (upper)     (units)

 g1:   AUTO   -2.000E+01 ~ +2.000E+01   (V      )
```

STATUS screen

Note If the setting of averaging is saved as the waveform function setting, the waveform decision is performed after averaging of setting number of times. It is identical manner in the auto-save function and auto-print function.

Reference Expressions used in averaging

(1) Time domain averaging

With time axis averaging, addition is performed in sync when the trigger condition is satisfied. Therefore, this type of averaging is meaningless unless sync is obtained.

① Simple additive averaging

- With simple additive averaging, take measurements using the SINGLE or REPEAT trigger mode. If the trigger is set, the AUTO trigger mode can also be used.

Averaging expression

$$\overline{A_i} = \frac{\sum_{i=1}^{N} A_i}{N} \qquad (1\text{-}5\text{-}1)$$

$\overline{A_i}$ Simple additive average of ith repetition
A_i ith input waveform
N Number of additions

② Exponential averaging

- With exponential averaging, use either the SINGLE or the REPEAT trigger mode.

Averaging expression

$$\overline{A_i} = \frac{(N-1)\overline{A_{i-1}} + A_i}{N} \qquad (1\text{-}5\text{-}2)$$

$\overline{A_i}$ Exponential average of ith repetition
A_i i th input waveform
N Number of setting

(2) Frequency domain averaging

Unlike time domain averaging, synchronization is not required in order to do frequency domain averaging.

① Simple additive averaging

- Averaging is performed for the specified number of repetitions, regardless of the trigger mode.
- The averaging expression is the same as that shown for time domain averaging in Expression (1-5-1).

② Exponential averaging

- Averaging is performed for the specified number of repetitions, regardless of the trigger mode.
- The averaging expression is the same as that shown for exponential averaging in Expression (1-5-2).

(3) Peak hold (frequency domain)

The specified number of data samples is captured and the maximum value is held for each frequency.

Note The start-up operation is re-initiated if the averaging type or number of repetitions is changed during the start operation.

Relationship between FFT analysis modes and averaging

FFT analysis mode	Y-axis (vertical axis)	Time axis averaging	Frequency axis averaging	Peak hold
[STR] Storage waveform	(LIN-MAG)	Yes	No	No
[LIN] Linear spectrum	LIN-REAL	Yes	Yes	No
	LIN-IMAG	Yes	Yes	No
	LIN-MAG	Yes	Yes	Yes
	LOG-MAG	Yes	Yes	Yes
	PHASE	Yes	No	No
[RMS] RMS spectrum	LIN-REAL	Yes	Yes	No
	LIN-IMAG	Yes	Yes	No
	LIN-MAG	Yes	Yes	Yes
	LOG-MAG	Yes	Yes	Yes
	PHASE	Yes	No	No
[PSP] Power spectrum	LIN-MAG	Yes	Yes	Yes
	LOG-MAG	Yes	Yes	Yes
[ACR] Auto correlation function	(LIN-MAG)	Yes	Yes	Yes
[HIS] Histogram	(LIN-MAG)	Yes	No	No
[TRF] Transfer function	LIN-REAL	Yes	No	No
	LIN-IMAG	Yes	No	No
	LIN-MAG	Yes	Yes	Yes
	LOG-MAG	Yes	Yes	Yes
	PHASE	Yes	No	No
[CSP] Cross power spectrum	LIN-REAL	Yes	Yes	No
	LIN-IMAG	Yes	Yes	No
	LIN-MAG	Yes	Yes	Yes
	LOG-MAG	Yes	Yes	Yes
	PHASE	Yes	No	No
[CCR] Cross correlation function	(LIN-MAG)	Yes	Yes	Yes
[IMP] Unit impulse response	(LIN-MAG)	Yes	Yes	Yes
[COH] Coherence function	(LIN-MAG)	Yes	Yes	Yes
[OCT] Octave analysis	LIN-MAG	Yes	Yes	Yes
	LOG-MAG	Yes	Yes	Yes

* With the Nyquist display, the same relationships hold for LIN, TRF, and CSP.

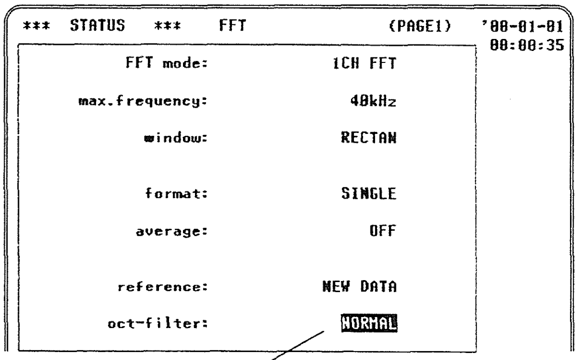
5.11 Setting the Octave Filter

- Octave filter selection is possible when octave analysis is selected.

Method (Screen for making this setting: the STATUS screen)

1. Using the cursor keys, move the flashing cursor to the "Oct-filter" item.
2. Set which octave filter is used according to the displays on the function keys.

Function key indication	*Meaning*
NORMAL	: Select "normal" mode
SHARP	: Select "sharp" mode

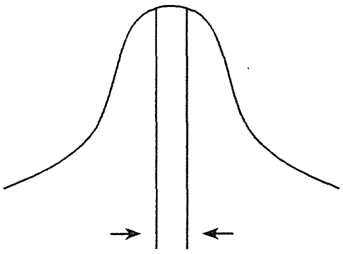


```
***  STATUS  ***    FFT                    (PAGE1)  '00-01-01
                                                     00:00:35
              FFT mode:                 1CH FFT
        max.frequency:                    40kHz
               window:                   RECTAN

               format:                   SINGLE
              average:                      OFF

            reference:                 NEW DATA
           oct-filter:                   NORMAL
```

Flashing cursor

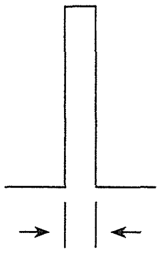
STATUS screen

- When "normal" is selected, analysis is performed using a filter characteristic that simulates the characteristic of the filter in octave analyzers commonly in use. (The characteristic of a meter using an analog filter is simulated.)
- When "sharp" is selected, spectra within the octave band are bundled for analysis, and results are not affected by spectra outside of the octave band.



Filter characteristic
with "normal" setting

1/1-octave band
(1/3-octave band)



Filter characteristic
with "sharp" setting

(These filter characteristics are within ANSI Class Ⅲ limits.)

Note Since this unit does not use an analog filter for analysis, spectrum bundling is performed while applying weighting corresponding to the above filter characteristics at the time of power spectrum capture.

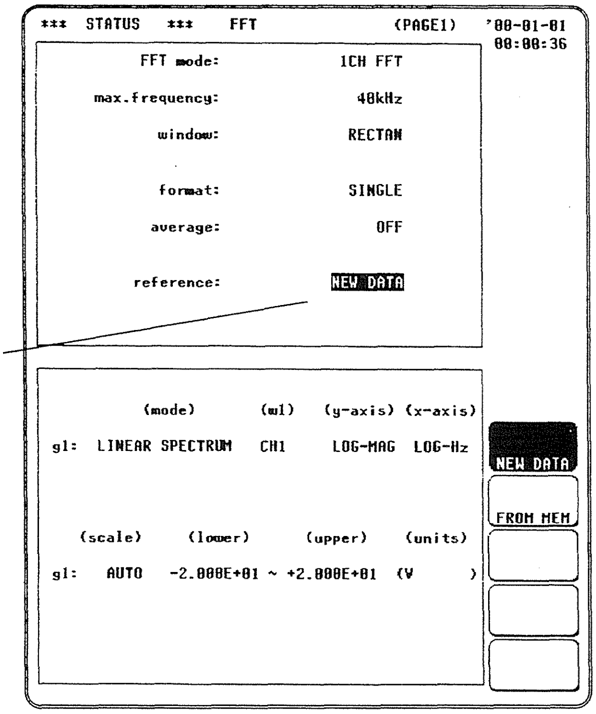
5.12 Setting the Reference Data

- Select the data to be used for FFT calculation.
- If you select "NEW DATA", 1000 points of data are captured and FFT calculation is performed when the START operation is initiated.
- If you select "FROM MEM", after the START operation, FFT calculation is performed using data that has previously been captured using the memory function. At this time, the starting and ending points for calculation can be set using the A and B cursors. FFT calculations are performed using the 1000 points of data that follow whichever of the two cursors is first.

Method (Screen for making this setting: the STATUS screen)

1. Using the cursor keys, move the flashing cursor to the "reference" item.
2. Select the desired data for FFT calculation according to the indications on the function keys.

Function key indication	*Meaning*
NEW DATA	: NEW DATA
FROM MEM	: FROM MEM



```
***  STATUS  ***     FFT                    (PAGE1)   '00-01-01
                                                       00:00:36
              FFT mode:              1CH FFT

        max.frequency:                 40kHz

               window:                RECTAN

               format:                SINGLE

              average:                   OFF

            reference:              NEW DATA


             (mode)          (wl)    (y-axis) (x-axis)
 gl:   LINEAR SPECTRUM       CH1      LOG-MAG  LOG-Hz


     (scale)      (lower)         (upper)      (units)
 gl:    AUTO    -2.000E+01 ~ +2.000E+01     (V        )
```

Flashing cursor

STATUS screen

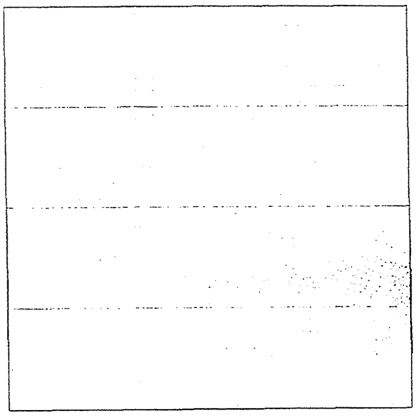
Note If "FROM MEM" is selected as the data to be used for FFT calculation, the maximum recording length recording length that can be set with the memory recorder function is as shown in the table below.

Number of channels used / Memory Capacity	8 ch	4 ch	2 ch	1 ch
1M words	1000 DIV	2000 DIV	5000 DIV	10000 DIV

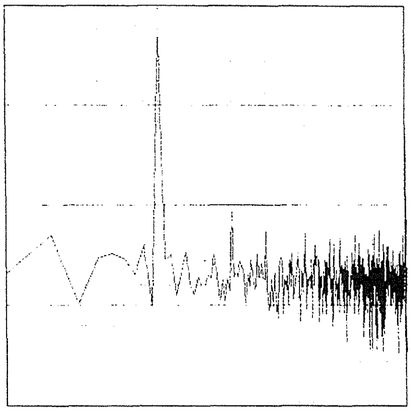
- When "FROM MEM" is selected as the reference data, trigger setting is not necessary because wave form data is not captured when START operation is initiated with the FFT function after capture of waveform data with the MEM function. However, the trigger mode becomes effective and, if "REPEAT" or "AUTO" is selected, waveform data captured with the MEM function is shifted by 1000 points at a time and the FFT operation is repeated until data end is encountered.

5.13 Setting the Interpolation Function

- It is possible to display and record the input signal (the sampled data) and FFT calculation waveform as they are, or after subjecting them to linear interpolation.



DOT display (without interpolation)

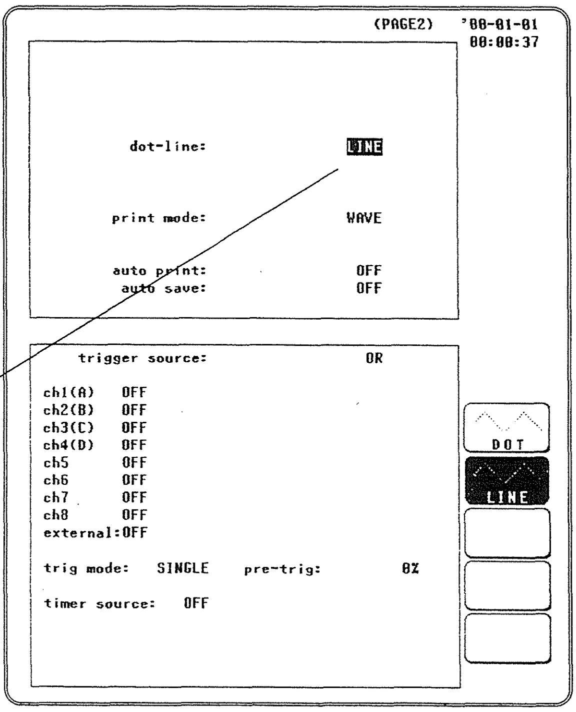


LINE display (with interpolation)

Method (Screen for making this setting: the STATUS screen (PAGE 2))

1. Using the cursor keys, move the flashing cursor to the "dot-line" item.
2. Make the setting according to the indications on the function keys.

Function key indication	*Meaning*
DOT	: linear interpolation is not performed. In principle, the sampled data or FFT calculated data are faithfully displayed as they are.
LINE	: linear interpolation is performed. The display is easier to view.



```
                                   (PAGE2)  '00-01-01
                                            00:00:37

        dot-line:                 LINE

        print mode:               WAVE

        auto print:               OFF
        auto save:                OFF

     trigger source:              OR

 ch1(A)   OFF
 ch2(B)   OFF
 ch3(C)   OFF
 ch4(D)   OFF
 ch5      OFF
 ch6      OFF
 ch7      OFF
 ch8      OFF
 external:OFF

 trig mode:   SINGLE    pre-trig:       0%

 timer source:   OFF
```

Flashing cursor

STATUS screen

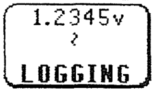
5.14 Recording on the Printer

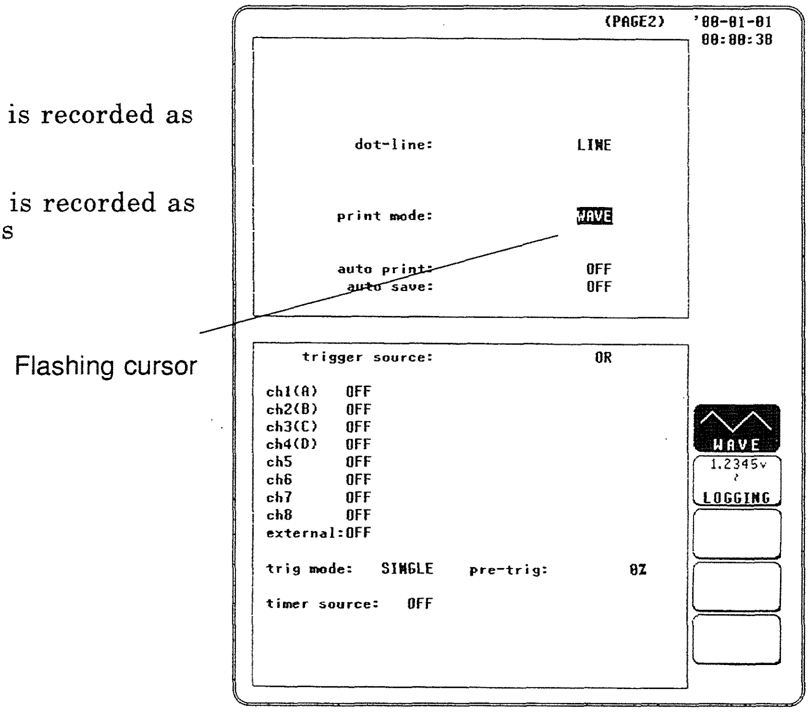
(1) Setting the style for recording the waveform on the printer (the print mode)

There are two styles for outputting the result of FFT calculation on the printer: as a waveform (WAVE) and as numerical values (LOGGING); either of these modes can be selected.

Method (Screen for making this setting: the STATUS screen (PAGE 2))

1. Press the STATUS key to switch to Page 2 of the STATUS screen.
2. Using the cursor keys, move the flashing cursor to the "print mode" item.
3. Select the desired mode according to the indications on the function keys.

Function key indication	*Meaning*
	: the input signal is recorded as a waveform
	: the input signal is recorded as numerical values



```
                                   (PAGE2)   '00-01-01
                                              00:00:38

              dot-line:                LINE

              print mode:              WAVE

              auto print:              OFF
              auto save:               OFF

        trigger source:                OR

  ch1(A)    OFF
  ch2(B)    OFF
  ch3(C)    OFF
  ch4(D)    OFF
  ch5       OFF
  ch6       OFF
  ch7       OFF
  ch8       OFF
  external:OFF

  trig mode:   SINGLE    pre-trig:        0%

  timer source:   OFF
```

STATUS screen

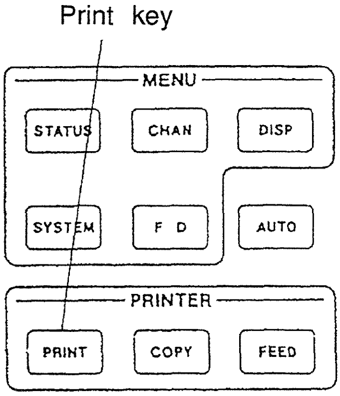
(2) Methods of printing

There are three printing methods:

① Manual printing

This prints out the stored data from one measurement.

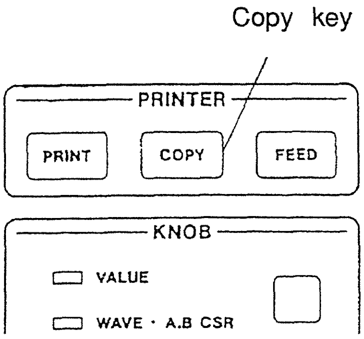
Method
- When measurement is finished, press the PRINT key.
- Because the measurement data is saved in memory, it can be reprinted as many times as required.



② Screen copy printing

It is also possible to make a direct hard copy of the current screen display when the "status" screen, the "channel" screen, the "display" screen, the "system" screen, or the "floppy disk control" screen is being shown.

Method
- Press the COPY key.
- The current screen display is printed out on the printer just as it is.



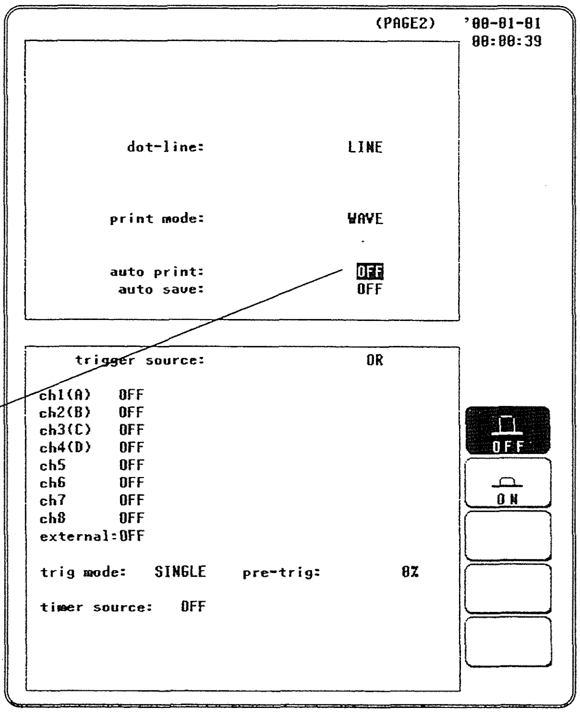
③ Auto-printing

This function automatically prints out the waveform of the FFT calculation result while simultaneously displaying it on the screen.

Method (Screen for making this setting: the STATUS screen (PAGE2))

1. Using the cursor keys, move the flashing cursor to the "auto print" item.
2. Select F2 (ON) according to the indications on the function keys.

Function key indication	*Meaning*
OFF	: auto print function disabled
ON	: auto print function



```
(PAGE2)   '00-01-01
          00:00:39

dot-line:        LINE

print mode:      WAVE

auto print:      OFF
 auto save:      OFF

trigger source:        OR

ch1(A)   OFF
ch2(B)   OFF
ch3(C)   OFF
ch4(D)   OFF
ch5      OFF
ch6      OFF
ch7      OFF
ch8      OFF
external:OFF

trig mode:   SINGLE    pre-trig:     0%

timer source:   OFF
```

Flashing cursor

STATUS screen

3. Press the START key, and measurement will commence. As the waveform is displayed on the screen, it is simultaneously printed out.

- Auto-printing can be used for both waveform printing (WAVE option) and numerical printing (LOGGING option).

Related items

- It is possible to supplement manual or auto printing of a waveform with a listing of settings or gauges. (8840 Instruction Manual Section 13.3.6 "Listing and Gauge Functions")
- The auto save function can also be used with the FFT function (8840 Instruction Manual Section 15.7 "Auto Save Function").

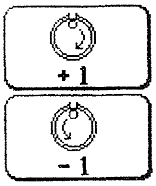
5.15 Setting Each Input Channel

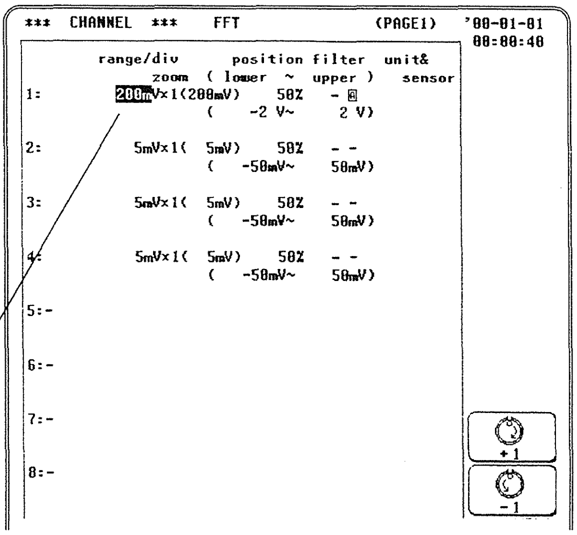
- Settings for each of the channels can be made on the CHANNEL screen or on the DISPLAY screen.
- The 8840 FFT can handle, at the most, 8 analog channels.

(1) Setting the voltage axis range (range/div)

- The voltage axis range (range/div) should be set for each channel.
- The value set for range/div denotes the voltage value for 1 DIV along the voltage axis (vertically).

Method (Screen for making this setting: the CHANNEL screen)
The settings are made by using the function keys or the rotary knob.

Function key indication	*Meaning*
	5, 10, 20, 50, 100, 200, 500 mV, 1, 2, 5, 10, 20V



```
***  CHANNEL  ***     FFT                    (PAGE1)   '00-01-01
                                                        00:00:40
          range/div      position filter  unit&
                zoom  ( lower  ~  upper )   sensor
1:          200mV×1(200mV)     50%    - Ⓐ
                      (     -2 V~      2 V)

2:            5mV×1(  5mV)     50%    - -
                      (    -50mV~    50mV)

3:            5mV×1(  5mV)     50%    - -
                      (    -50mV~    50mV)

4:            5mV×1(  5mV)     50%    - -
                      (    -50mV~    50mV)

5:-

6:-

7:-

8:-
```

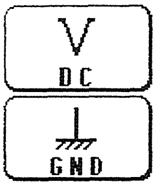
CHANNEL screen

(2) Setting the input coupling

Method (Screen for making this setting: the CHANNEL screen)

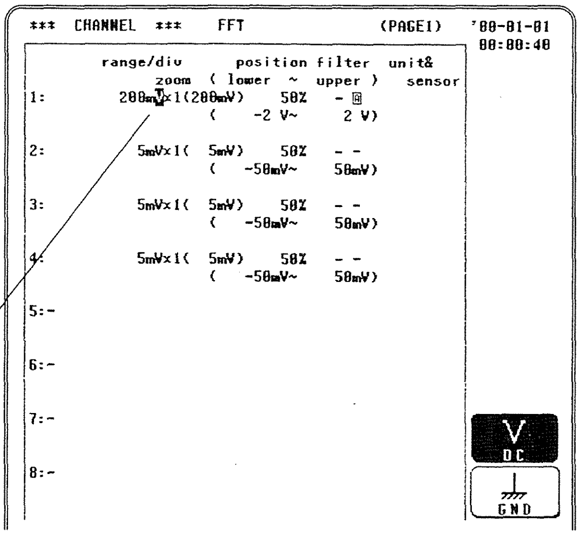
The selections are made according to the displays on the function keys.

Function key indication *Meaning*



: The input signal is directly connected to the input amplifier. This allows a DC component to be measured.

: The input signal is not connected. This allows the zero position to be checked.



```
***  CHANNEL  ***    FFT                    (PAGE1)   '00-01-01
                                                      00:00:40
          range/div      position filter  unit&
               zoom  ( lower  ~  upper )   sensor
1:        200mV×1(200mV)    50%   - A
                     (    -2 V~     2 V)

2:         5mV×1(  5mV)    50%   - -
                     (   -50mV~    50mV)

3:         5mV×1(  5mV)    50%   - -
                     (   -50mV~    50mV)

4:         5mV×1(  5mV)    50%   - -
                     (   -50mV~    50mV)

5:-

6:-

7:-

8:-
```

Flashing cursor

CHANNEL screen

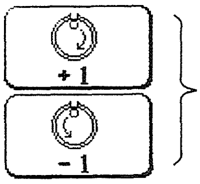
(3) Voltage axis magnification

- The magnification ratio along the voltage axis should be set for each channel.
- Magnification allows detailed observations which fully exploit the 12-bit A/D resolution.

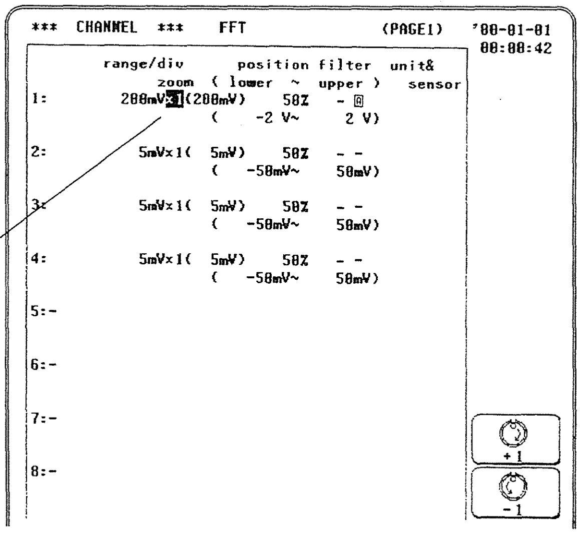
Method (Screen for making this setting: the CHANNEL screen)

- The settings are made by using the function keys or the rotary knob.
- In the FFT function, the histogram waveform is only effective.

Function key indication *Meaning*



×8,×4,×2,×1,×1/2



```
***  CHANNEL  ***    FFT                    (PAGE1)   '00-01-01
                                                      00:00:42
          range/div      position filter  unit&
               zoom  ( lower  ~  upper )   sensor
1:        200mV×1(200mV)    50%   - A
                     (    -2 V~     2 V)

2:         5mV×1(  5mV)    50%   - -
                     (   -50mV~    50mV)

3:         5mV×1(  5mV)    50%   - -
                     (   -50mV~    50mV)

4:         5mV×1(  5mV)    50%   - -
                     (   -50mV~    50mV)

5:-

6:-

7:-

8:-
```

Flashing cursor

CHANNEL screen

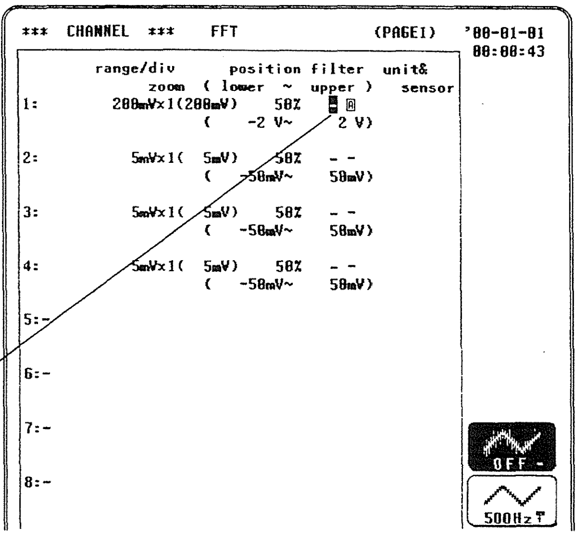
(4) Low-pass filter

- The internal low-pass filter of the input units can be set.
- The internal filter can be used to limit the frequency band of the input signal.
- Use of the low-pass filter can eliminate the following phenomena:
- Thickening of the recording line during level recording in the recorder function mode, due to ripple components and noise in the signal from high speed sampling and high band amplification.
- Thickening of the recording line because ripples are present in the output of transducers and the like.

Method (Screen for making this setting: the CHANNEL screen)

Make the setting using the function keys or the rotary knob.

Function key indication	*Meaning*
OFF -	: No low-pass filter is used.
500Hz ⊤	: A filter with 500 Hz cutoff is used.
5Hz ■	: A filter with 5 Hz cutoff is used.


```
***  CHANNEL  ***    FFT                    (PAGEI)   '00-01-01
                                                       00:00:43
        range/div       position filter  unit&
              zoom  ( lower  ~  upper )   sensor
1:       200mVx1(200mV)    50%   ■ A
                    (   -2 V~     2 V)
2:          5mVx1(  5mV)    50%   - -
                    (   -50mV~    50mV)
3:          5mVx1(  5mV)    50%   - -
                    (   -50mV~    50mV)
4:          5mVx1(  5mV)    50%   - -
                    (   -50mV~    50mV)
5:-
6:-
7:-
8:-
```

Flashing cursor

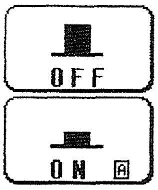
CHANNEL screen

(5) Anti-aliasing filter

- The 8919 FFT analog unit is equipped with a built-in anti-aliasing filter to prevent aliasing distortion. The cutoff frequency is automatically set according to the selected frequency range.

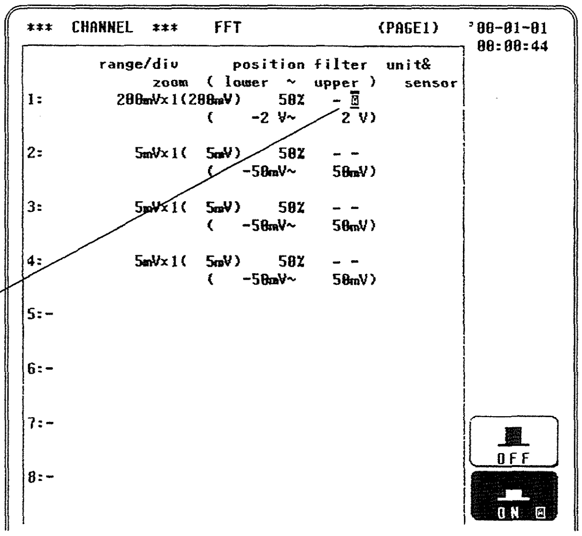
Method (Screen for making this setting: the CHANNEL screen)
Select according to the function key indication.

Function key indication | *Meaning*



: Anti-aliasing filter not used.

: Anti-aliasing filter used.



```
***  CHANNEL  ***    FFT                 (PAGE1)   '00-01-01
                                                    00:00:44
        range/div      position filter  unit&
             zoom  ( lower  ~  upper )   sensor
1:       200mVx1(200mV)     50%    - ▯
                   (    -2 V~      2 V)

2:          5mVx1(  5mV)    50%    - -
                   (    -50mV~     50mV)

3:          5mVx1(  5mV)    50%    - -
                   (    -50mV~     50mV)

4:          5mVx1(  5mV)    50%    - -
                   (    -50mV~     50mV)

5:-

6:-

7:-

8:-
```

Flashing cursor

CHANNEL screen

Frequency range	TIME/DIV
80 kHz #	500 μs/DIV
40 kHz	1 ms/DIV
20 kHz	2 ms/DIV
8 kHz	5 ms/DIV
4 kHz	10 ms/DIV
2 kHz	20 ms/DIV
800 Hz	50 ms/DIV
400 Hz	100 ms/DIV
200 Hz	200 ms/DIV
80 Hz	500 ms/DIV
40 Hz	1 s/DIV
20 Hz	2 s/DIV
8 Hz *	5 s/DIV
4 Hz *	10 s/DIV
2 Hz *	20 s/DIV
667 mHz *	1 min/DIV
333 mHz *	2 min/DIV
133 mHz *	5 min/DIV

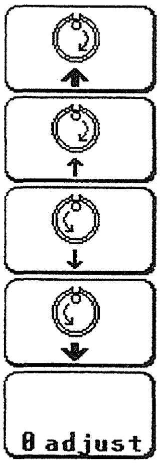
Note With the 8919 FFT analog unit, the anti-aliasing filter's cutoff frequency is the same as the frequency range.
(# Anti-aliasing is OFF with the 80 kHz range.)
(* The cutoff frequency is 20 Hz.)

(6) Position

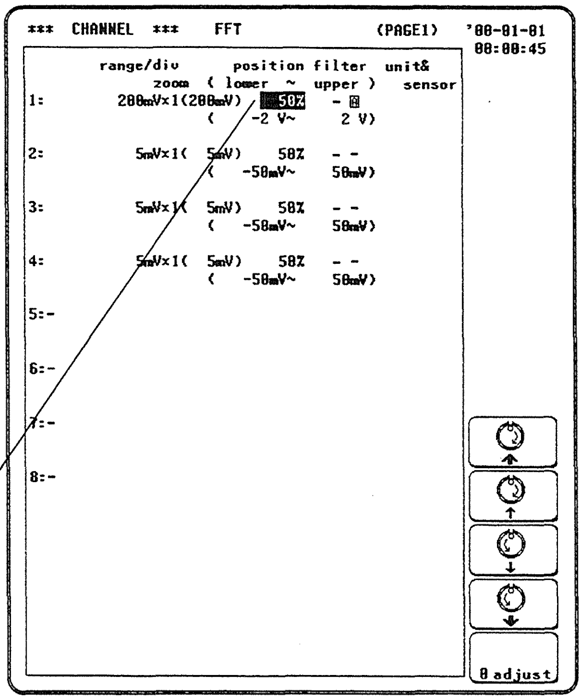
- The position can be set for each channel (in the FFT function, the histogram waveform is only effective).
- The range for the position varies according to the magnification ratio along the voltage axis.

Method (Screen for making this setting: the CHANNEL screen)

Make the setting using the function keys or the rotary knob.

Function key indication	*Meaning*
	When the magnification ratio is 1, the range is from -28% to 128%. For other cases, see the table below. : (Zero Adjustment)

Flashing cursor



```
***  CHANNEL  ***    FFT                  (PAGE1)   '00-01-01
                                                     00:00:45
       range/div       position filter  unit&
             zoom  ( lower  ~  upper )   sensor
1:      200mVx1(200mV)   50%    - A
                   (   -2 V~     2 V)

2:        5mVx1(  5mV)    50%    - -
                   (   -50mV~   50mV)

3:        5mVx1(  5mV)    50%    - -
                   (   -50mV~   50mV)

4:        5mVx1(  5mV)    50%    - -
                   (   -50mV~   50mV)

5:-

6:-

7:-

8:-
```

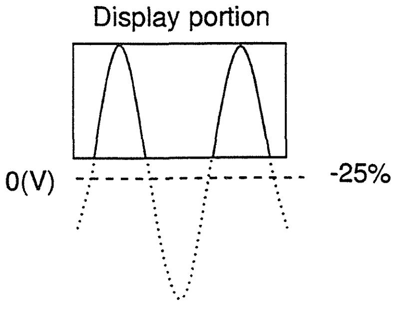
CHANNEL screen

Magnification ratio	X1/2	X1	X2	X4	X8
Position range (%)	36 to 64	-28 to 128	-156 to 256	-412 to 512	-924 to 1024

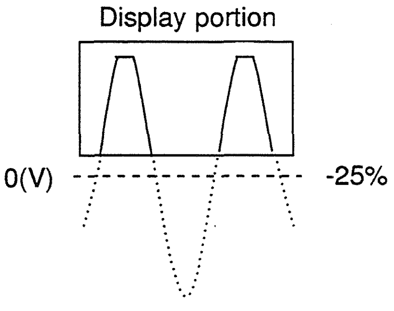
Note When the anti-aliasing filter is ON, the waveform display will be limited by making a following setting. (When the anti-aliasing filter is OFF, the whole amplitude of the waveform is displayed on the screen.)

Magnification ratio	X1/2	X1	X2	X4	X8
Position range (%)	40 or less / 60 or more	-20 or less / 120 or more	-140 or less / 240 or more	-380 or less / 480 or more	-860 or less / 960 or more

Example When the magnification ratio is X1:



Anti-aliasing filter:OFF



Anti-aliasing filter:ON

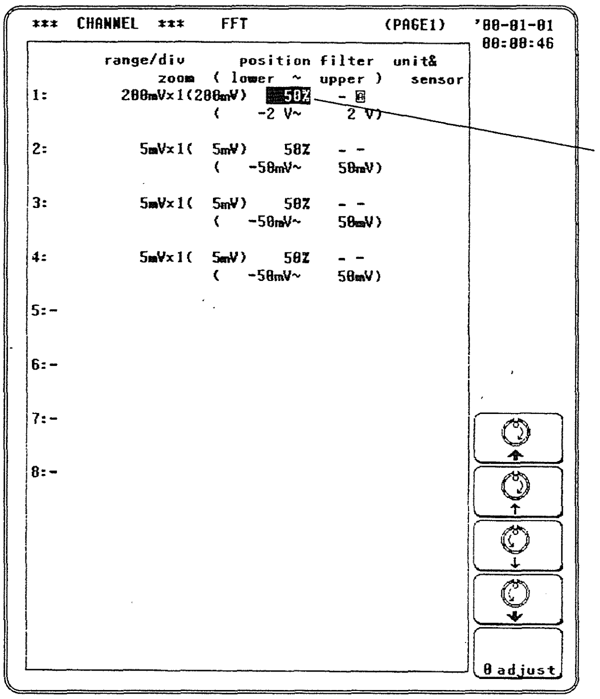
5.16 Zero Adjustment

This function accurately adjusts the waveform to the origin position for an input voltage of 0V.Do this zero adjustment whenever the waveform deviates from the origin position; e.g., while taking extended measurements.

Method (Screen for making this setting: the CHANNEL screen)

Always allow at least 1 hour warmup time before carrying out this procedure, to ensure that the internal temperature of the unit has stabilized.

1. Using the cursor keys, move the flashing cursor to the "position" item.
2. Press function key F5 (0 adjust), and all of the channels will be calibrated at once.
   This operation should be performed whenever the voltage axis range is changed.



```
***  CHANNEL  ***    FFT                  (PAGE1)   '00-01-01
                                                     00:00:46
           range/div        position filter  unit&
                 zoom  ( lower  ~  upper )   sensor
1:       200mVx1(200mV)   50%    - ®
                       (     -2 V~      2 V)

2:          5mVx1(  5mV)    50%    - -
                       (    -50mV~    50mV)

3:          5mVx1(  5mV)    50%    - -
                       (    -50mV~    50mV)

4:          5mVx1(  5mV)    50%    - -
                       (    -50mV~    50mV)

5:-

6:-

7:-

8:-
```

Flashing cursor

CHANNEL screen

Note

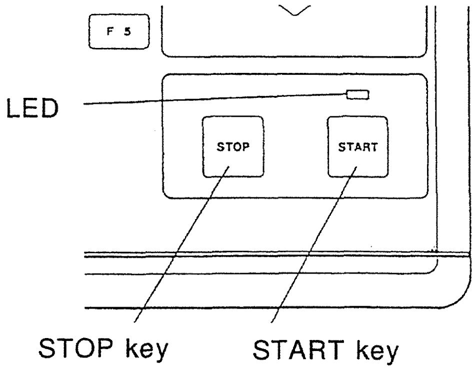
- Zero adjustment cannot be performed while measurement is taking place.
- Do zero adjustment again after changing input units.
- The 8918 temperature unit does not have a zero adjustment function.

5.17 Starting and Stopping Measurement

Measurement is started by pressing the START key. After pressing the START key, the LED above the key lights until the FFT calculation is completed, then goes out.

Method

1. Press the START key. Measurement and FFT calculation starts.
2. Press the STOP key. Measurement and FFT calculation stops.



Note

(1) Starting and stopping measurements in the three trigger modes

a. When the trigger mode is SINGLE.

Press the START key and, if the trigger conditions hold, data of length equal to 1000 points will be read in and stored. Then, even if the STOP key is not pressed, the system will go into the measurement finished state.

b. When the trigger mode is REPEAT:

Press the START key and, if the trigger conditions hold, data of length equal to 1000 points will be read in and stored. Thereafter, every time the trigger conditions hold, data will be read in and the contents of the memory will be overwritten.

c. When the trigger mode is AUTO:

Press the START key and, if the trigger conditions hold, data of length equal to 1000 points will be read in and stored. Even if the trigger conditions do not hold, data of length equal to 1000 points will be automatically read in and stored after about a second. The operation is repeatedly. Press the STOP key to terminate the measurement.

(2) Stopping measurement

Even if the STOP key is pressed, calculations will continue until reading in and storage of waveform data and FFT analysis have finished. Note, however, that if the STOP key is now pressed again, waveform capture or FFT calculation is aborted and all data obtained to that point is lost. If, after the STOP key has been pressed once, the START key is pressed before the reading in and storage of waveform data or FFT calculation has terminated, then a restart occurs, and the situation is identical to that which was the case at the very beginning, when measurement started.

5.18 Using the A and B Cursors

- You can use the A and B cursors to measure time differences, frequency differences, and voltage differences while getting a direct digital readout on the screen.
- In the FFT function, only the cross cursors can be used.

The cross cursors

As a cross cursor is moved, the intersection of the cross (the trace point) traces the waveform of the specified screen.

● A and B cursors used individually

t : time interval from the trigger position to the trace point
v : voltage difference from 0 V
f : frequency

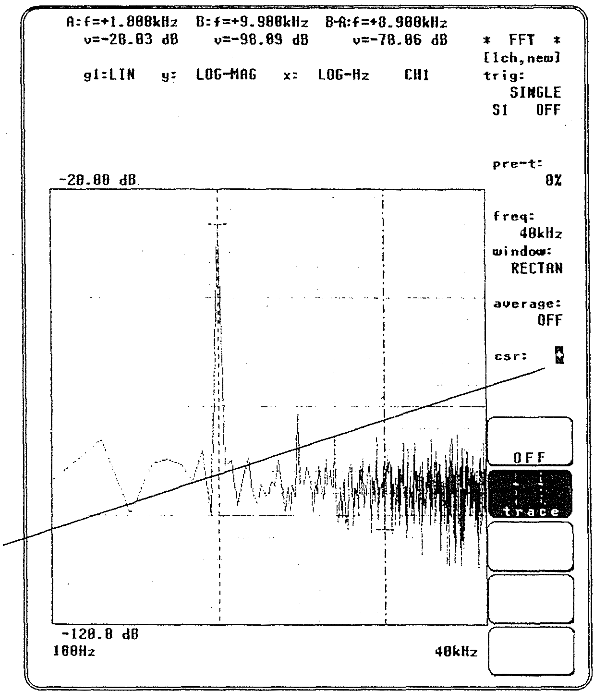
● A and B cursors used together

t : time interval between the trace points
v : voltage difference between the trace points
f : frequency differences between the trace points

Method (Screen for making this setting: the DISPLAY screen)

1. Using the cursor keys, move the flashing cursor to the "csr" item.
2. According to the displays on the function keys, select the desired line cursor.

Function key indication	*Meaning*
OFF	: do not use the A and B cursors
trace	: cross cursor



```
A:f=+1.000kHz  B:f=+9.900kHz  B-A:f=+8.900kHz
  v=-20.03 dB     v=-98.09 dB      v=-78.06 dB
  g1:LIN   y:  LOG-MAG   x:  LOG-Hz    CH1
-20.00 dB
-120.0 dB
100Hz                                   40kHz
```

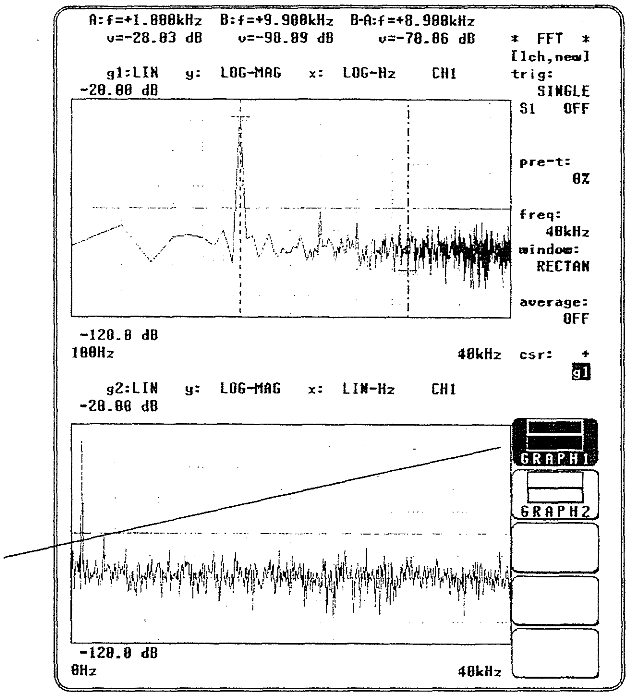
```
* FFT *
[1ch,new]
trig:
  SINGLE
 S1   OFF
pre-t:
      0%
freq:
   40kHz
window:
  RECTAN
average:
     OFF
csr:
```

Flashing cursor

DISPLAY screen

3. When the (DUAL) display format is selected, designate which graph the cross cursor will trace.

Function key indication	*Meaning*
GRAPH1	: Trace graph 1.
GRAPH2	: Trace graph 2.



```
A:f=+1.000kHz  B:f=+9.900kHz  B-A:f=+8.900kHz
  v=-28.03 dB    v=-98.89 dB      v=-70.86 dB    *  FFT  *
                                                 [1ch,new]
  g1:LIN   y:  LOG-MAG   x:  LOG-Hz    CH1       trig:
-20.00 dB                                           SINGLE
                                                  S1   OFF

                                                  pre-t:
                                                        0%

                                                  freq:
                                                     40kHz
                                                  window:
                                                    RECTAN

                                                  average:
                                                       OFF
-120.0 dB
100Hz                                    40kHz    csr:    +
                                                         g1
  g2:LIN   y:  LOG-MAG   x:  LIN-Hz    CH1
-20.00 dB

-120.0 dB
0Hz                                      40kHz
```

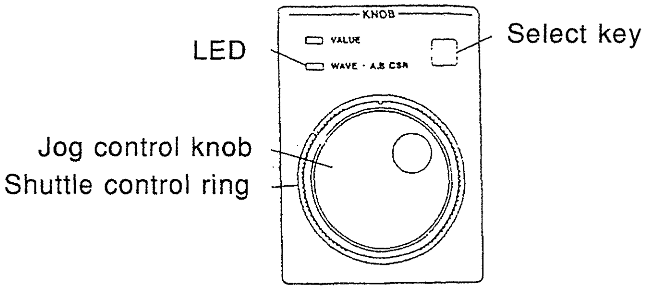
Flashing cursor

DISPLAY screen

4. Press the select key, and the LED for WAVE · AB CSR will be illuminated.
   (Movement of the Jog and Shuttle controls now performs [AB cursor].)
5. Select the cursor to be moved according to the display on the function keys.

Function key indication	*Meaning*	
A	: move the A cursor	Press the funciton key switching that function key display to reverse video, and the cursor will then move.
B	: move the B cursor	

6. Turn the Jog or Shuttle controls to move the cross cursor.
   - t, V, and f are derived according to the trace point.



7. To terminate, press the select key, and the LED for WAVE · AB CSR will go off. Using the cursor keys, move the flashing cursor to the "csr" item to off.

5.19 Waveform Decision Function

With the FFT function, the waveform decision function can be used when SINGLE or NYQUIST is selected as the display format.

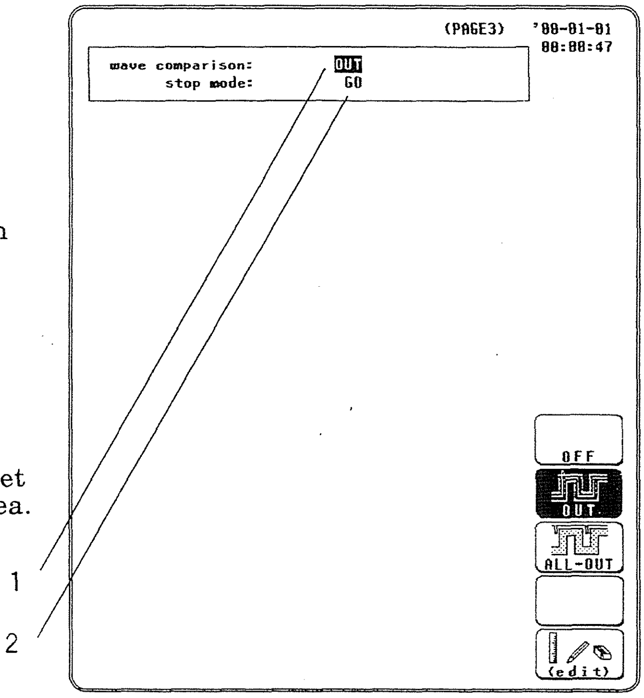
Method (Screen for making this setting: the STATUS screen, PAGE 3)

- From Page 1 of the STATUS screen, press the STATUS key twice to get to Page 3. (This can also be done by pressing a cursor key and holding it down.)
- Using the cursor keys, move the flashing cursor as described below in turn to the items designated by the numbers in the figure below, and perform the settings.

1. Setting the waveform decision mode (wave comparison)

   Make the selection according to the displays on the function keys.

Function key indication	*Meaning*
OFF	: do not perform waveform decision
OUT	: make an NG decision if the waveform leaves the decision area at any point.
ALL-OUT	: make an NG decision if the waveform is entirely outside the decision area.
(edit)	: enter the editor in order to set up the waveform decision area.



(PAGE3) '00-01-01 00:00:47

wave comparison: OUT
stop mode: GO

STATUS screen

2. Setting the stop mode

Select whether operation should stop after a GO result, an NG result, or either. Make the selection according to the displays on the function keys.

Function key indication	*Meaning*
GO	: stop operation only after a pass.
NG	: stop operation only after a fail.
GO&NG	: stop operation regardless of the decision result.

- For a detailed explanation of the editor, refer to Section 11 of the 8840 Instruction Manual.

5.20 Floppy Disk Operation

■ Items stored and required disk space

(1) Settings

- It is possible to save the settings for each measurement function.
  Space occupied on the floppy disk : 3 sectors
  (1 sector = 1024 bytes)

(2) Measurement data (WAVE)

- Storing the waveform displayed as the result of FFT calculation.
  Memory capacity required for measurement data (in sectors):

With 1CH FFT mode;	
SINGLE screen	24 sectors
DUAL or NYQUIST screen	36 sectors
With 2CH FFT mode;	
SINGLE screen	34 sectors
DUAL or NYQUIST screen	45 sectors

Note When measurement data is loaded from floppy disk, several seconds may be required after loading is completed in order to do the calculations that are necessary to display the waveform.

(3) Waveform decision area (AREA)

- For the FFT function mode, it is possible to save a waveform decision area which the user has created.
- Only the settings necessary for waveform decision when a waveform decision area has been created are saved simultaneously.
  Memory capacity required for a waveform decision area: 32 sectors

- For additional details on operating procedures, see Chapter 15 of the 8840 Instruction Manual.

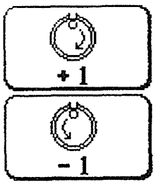
5.21 Engineering Units

With the 8840, the reference value for the logarithmic amplitude of linear spectra (LIN) is 1 Vpeak, for RMS spectra (RMS) it is 1 Vrms, and for power spectra (PSP) it is (1 Vrms)^2. However, a different 0 dB reference value is used in some sensor equipment, while some equipment has inscription plates indicating the dB level that corresponds to 1 Vrms or the number of volts rms that are output at the reference value (0 dB).
In order to match the value measured by the sensor with the display of this unit, it is possible to multiply or divide the result of calculation by an arbitrary constant (either (eu/v) or (v/eu), as appropriate).

Method (Screen for making this setting: the SYSTEM screen)

Pressing the SYSTEM key causes the SYSTEM screen to be displayed.

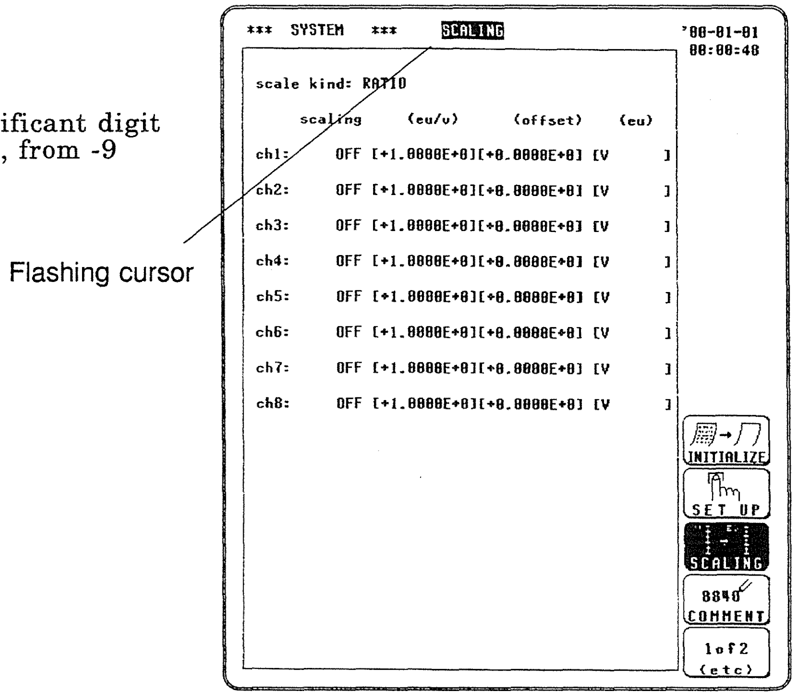
1. Press F3 (SCALING) and the scaling setting screen will appear.
2. If you want to use engineering units, select ON(SCI) or ON(ENG).
3. Set (eu/v) and (offset).
   - (eu/v) and (offset) can be set within the range -9.999E+9 to +9.999E+9. When using an engineering unit, set (offset) to 0.
   - When you want to use (v/eu), set the reciprocal value with (eu/v).
   - Move the flashing cursor to each digit to set it.

Function key indication	*Meaning*
	from 0 through 9 (for the most significant digit and the exponent, from -9 through +9)

Flashing cursor

$a = \boxed{+0}\ .\ 000E+0$

Mantissa Exponent



```
***  SYSTEM  ***   SCALING                          '00-01-01
                                                     00:00:48
scale kind: RATIO

    scaling     (eu/v)        (offset)      (eu)
ch1:     OFF [+1.0000E+0][+0.0000E+0] [V       ]
ch2:     OFF [+1.0000E+0][+0.0000E+0] [V       ]
ch3:     OFF [+1.0000E+0][+0.0000E+0] [V       ]
ch4:     OFF [+1.0000E+0][+0.0000E+0] [V       ]
ch5:     OFF [+1.0000E+0][+0.0000E+0] [V       ]
ch6:     OFF [+1.0000E+0][+0.0000E+0] [V       ]
ch7:     OFF [+1.0000E+0][+0.0000E+0] [V       ]
ch8:     OFF [+1.0000E+0][+0.0000E+0] [V       ]
```

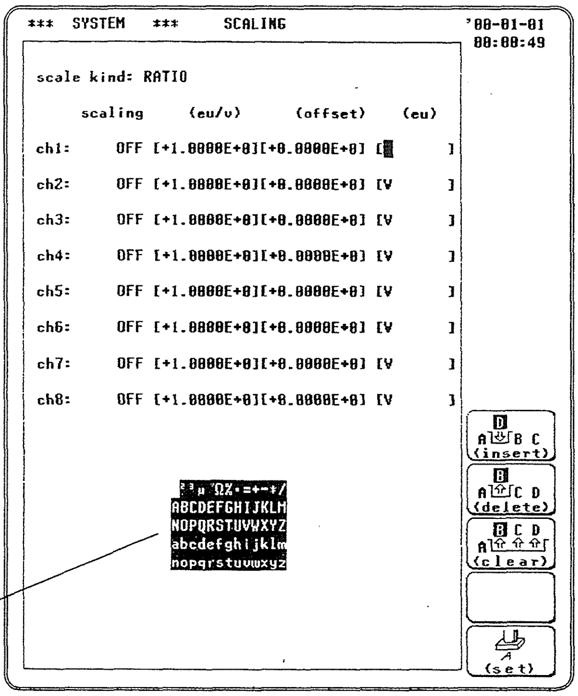
DISPLAY screen

4. Input the external unit name (eu).
- Input the name for the physical units of each channel.
- The unit name can be up to seven characters long.
- Bring the flashing cursor into the (eu) column and a character selection window will appear.

① Use the rotary knob to select each character in turn.

② Press the function key F5 (set) to select the character indicated by the cursor in the character selection window, and the flashing cursor will move one character to the right in the unit name field, so that the next character can be input (the right cursor key has the same effect). Repeat steps ① and ② to input the entire external unit name.

Function key indication	*Meaning*
D A B C (insert)	: Insert one character before the position of the flashing cursor.
B A C D (delete)	: Delete the character at the flashing cursor position.
B C D A (clear)	: Delete all the characters at and after the flashing cursor position.
A (set)	: Move the flashing cursor one space to the right.



```
***  SYSTEM  ***      SCALING                                '00-01-01
                                                              00:00:49
scale kind: RATIO

      scaling     (eu/v)       (offset)      (eu)
ch1:      OFF [+1.0000E+0][+0.0000E+0] [         ]
ch2:      OFF [+1.0000E+0][+0.0000E+0] [V        ]
ch3:      OFF [+1.0000E+0][+0.0000E+0] [V        ]
ch4:      OFF [+1.0000E+0][+0.0000E+0] [V        ]
ch5:      OFF [+1.0000E+0][+0.0000E+0] [V        ]
ch6:      OFF [+1.0000E+0][+0.0000E+0] [V        ]
ch7:      OFF [+1.0000E+0][+0.0000E+0] [V        ]
ch8:      OFF [+1.0000E+0][+0.0000E+0] [V        ]
```

Window

DISPLAY screen

Reference

Example of setting engineering units

Assume that the overall level of the power spectrum is 5 dB and that the noise meter reading is 18 dB. By increasing the 8840 display value by 13 dB, the 5 dB signal can be displayed as 18 dB on the screen of the 8840. Since the 8840 uses a reference value of 1 Vrms for 0 dB, the required multiplication value can be obtained by the following expression. This is the value that is set with (EU/V) of the engineering unit.

$$20 \cdot \log_{10} \frac{(EU/V)}{1Vrms} = 13 \text{ (dB)}$$

$$\therefore (EU/V) = 10^{\frac{13}{20}} = 4.46683 \ (Vrms)$$

Since the engineering units allow the exponent to be set within the range -9.999E+9 to +9.999E+9, the value is input as follows.

$$(EU/V) = 4.467E + 0$$

5.22 Decibel/Voltage conversion

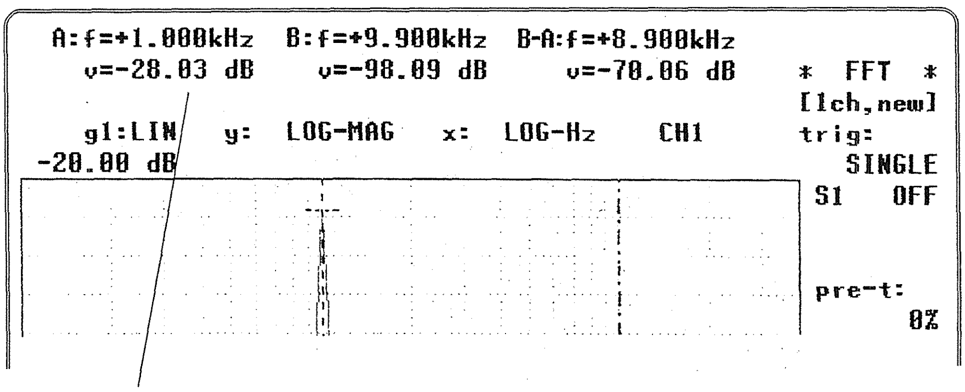
(1) Linear spectrum and RMS spectrum in the FFT calculation, and [dB] used on the chart and the measurement voltage [V] in the octave can be converted using the following formula.

Linear spectrum octave analysis $$dB = 20 \cdot \log_{10}\frac{V}{1Vrms}$$

RMS spectrum $$dB = 20 \cdot \log_{10}\frac{V}{1Vrms}$$

Therefore, $V = 10^{\frac{dB}{20}}$

Example



```
A:f=+1.000kHz  B:f=+9.900kHz  B-A:f=+8.900kHz
   v=-28.03 dB    v=-98.09 dB      v=-70.06 dB    *  FFT  *
                                                  [1ch,new]
  g1:LIN   y:  LOG-MAG   x:  LOG-Hz      CH1      trig:
-20.00 dB                                            SINGLE
                                                  S1   OFF

                                                  pre-t:
                                                         0%
```

Peak value

From the graph, a peak value of -28.03 dB can be converted to a voltage value as follows.

$$\begin{aligned} V &= 10^{\frac{-28.03}{20}} \\ &= 0.03967\ldots \\ &\fallingdotseq 0.0397\ (V) \end{aligned}$$

(2) For the transfer function, [dB] used on the chart indicates the ratio between two channels.

$$dB = 20 \cdot \log_{10}\frac{W2\,voltage}{W3\,voltage}$$

(3) For the power spectrum, and cross power spectrum.

$$dB = 10 \cdot \log_{10}V^2$$

conversion

Chapter 6
8919 FFT Analog Unit

6.1 Overview

- The 8919 FFT analog unit is used for the 8840 Memory HiCorder.
- The 8919 FFT analog unit allows line voltages of up to 100 V AC to be recorded directly.
- The 8919 is equipped with a built-in anti-aliasing filter to suppress aliasing.
- The anti-aliasing filter can be turned on or off using the memory recorder or FFT function.
- The anti-aliasing filter's cutoff frequency is automatically set according to the setting of the frequency axis (or time axis) range.

6.2 Specifications

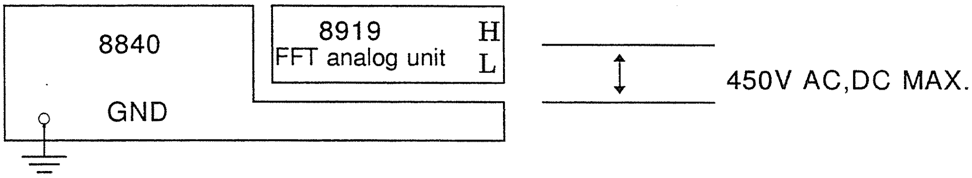
(Accuracy at 23 ± 5 ℃, after 1 hour warm-up time) Accuracy guaranteed for six months.)

Measurement ranges	5, 10, 20, 50, 100, 200, 500 mV/DIV 1, 2, 5, 10, 20 V/DIV
DC amplitude accuracy	± 0.25% f.s.
Zero position accuracy	± 0.1% f.s. (after zero adjustment)
Temperature characteristic	gain ± 0.02% f.s./℃ Zero position ± 0.015% f.s./ ℃
Frequency characteristic	DC to 100 kHz ± 3 dB
Noise	180μ Vp-p (typical) maximum sensitivity range, with input shorted
Common mode rejection ratio	100 dB minimum (at 50 Hz or 60 Hz and with signal source resistance 100Ω maximum)
Low-pass filter	Cutoff frequency of about 5 Hz or 500 Hz. Can be turned on and off. Attenuation is -6 dB/OCT
Anti-aliasing filter	Cutoff frequency (fc) of 20, 40, 80, 200, 400, 800, 2k, 4k, 8k, 20k, or 40k (Hz)
Input type	Unbalanced (floating)
Input resistance and capacitance	1MΩ ± 1%, about 27 pF (at 100 kHz)
A/D resolution	12 bits
Maximum sampling speed	200 kS/s
Input terminals	2 terminals (for banana plugs)
Permitted input voltage	500 V (DC+AC peak)
Maximum floating voltage	450 V AC or DC (between input unit and frame, between input units)
Dimensions and weight	20mm(H) × 110mm(W) × 88mm(D) approx. (excluding projections); 110 g approx.
Accessories	9574 cables (1)

6.3 Safety Requirements

⚠ DANGER

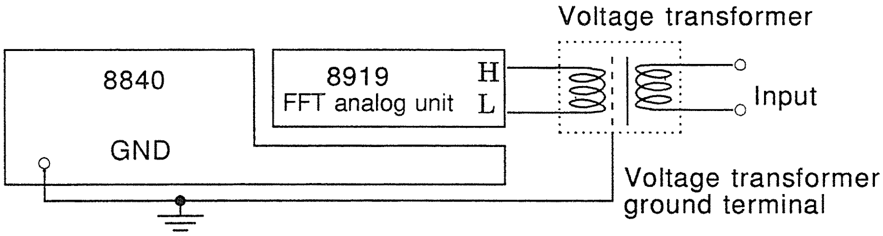
- **If any metallic portions of the input cables are exposed, there is a danger of electric shock. Use only the supplied 9574 input cables.**
- **The 8919 FFT analog unit and the 8840 frame are insulated.**
- **The maximum floating voltage between the inputs of the 8919 units and the frame of the 8840, or with other input units, is 450V AC/DC. To avoid the danger of electric shock or damage to the equipment, ensure that the applied voltage never exceeds the maximum floating voltage.**
- **The maximum floating voltage does not change even when using an attenuator with the input, for example.**



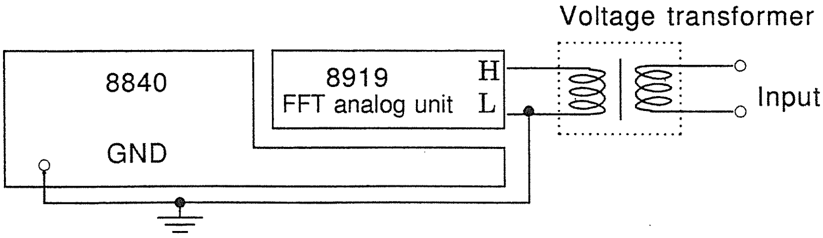
⚠ DANGER

The maximum permitted input voltage to the 8919 is 500V (DC + AC peak). To avoid the danger of electric shock or damage to the equipment, ensure that the applied voltage never exceeds this level.

- When making measurements on an AC power line using a voltage transformer, for example, ensure that the transformer is appropriately grounded as illustrated below.



(a) When the voltage transformer has a ground terminal



(b) When the voltage transformer has no ground terminal

⚠

6.4 Replacement Procedure

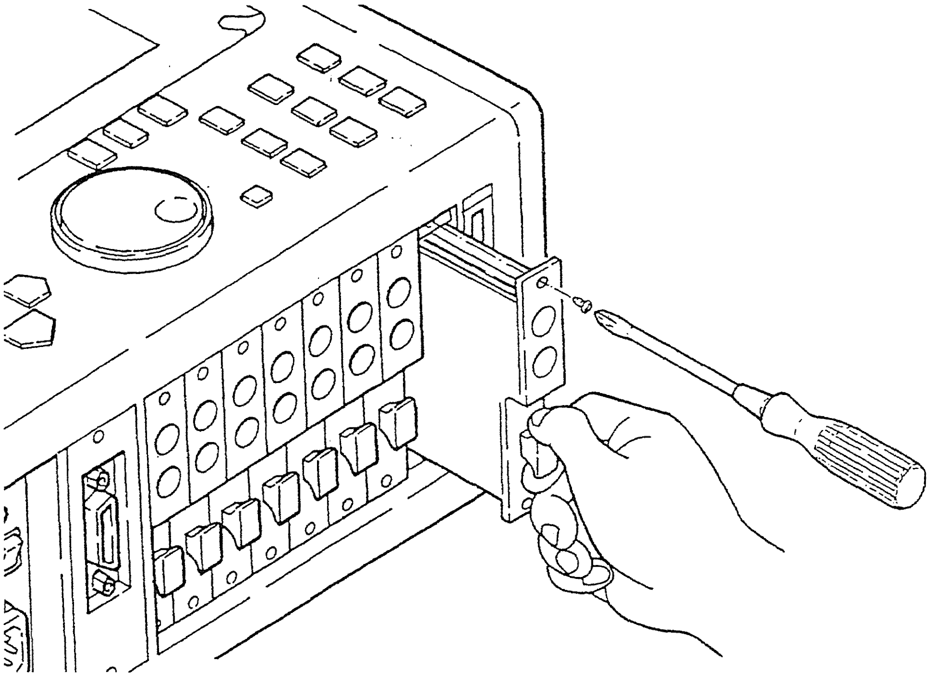
This section describes how to replace the input units.
The following procedure describes how to remove an input unit; for installing the input unit,reverse the procedure.

① Remove the input cables from all the input units.
② Power off the 8840 main unit, and disconnect the power cord.

⚠ DANGER

To avoid the danger of electric shock, always disconnect the input cables and the power cord before replacing input units.

③ Remove the two fixing screws with a Phillips screwdriver, as shown in the figure below.
④ Holding the handles at the center of the input unit, pull it out of the main unit.

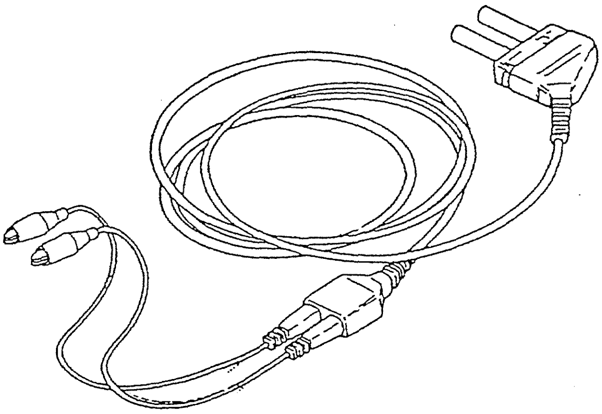


⚠WARNING

- **To avoid the danger of electric shock, never operate the 8840 unit with an input unit removed.**
- **If you should wish to use the unit after removing an input unit, fit a blanking panel over the opening of the removed unit.**

6.5 Input Cables

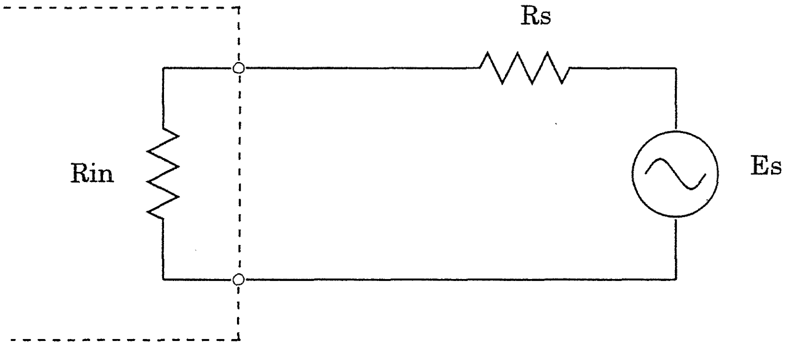
Only use the special purpose 9574 input cables when connecting to the 8919 FFT analog units.
The cables are approximately 1.7 m long, and the portion which plugs into the 8919 has a plastic cover for added safety.



9574 input cable

6.6 Measurement Errors Caused by Signal Source Internal Resistance

Measurement errors may result if the internal resistance of the signal source is high compared to the internal resistance of the 8840 unit.



Es = signal voltage
Rs = signal source resistance
Rin = input resistance

$$\text{Measurement error} = Es\left(1 - \frac{Rin}{Rs + Rin}\right)$$

Example The internal resistance of the 8840 is approximately 1 MΩ. Therefore, if the signal source resistance is 1 kΩ, measurement error is increased by approximately 0.1%.

Chapter 7
Screen Data File Saving Function

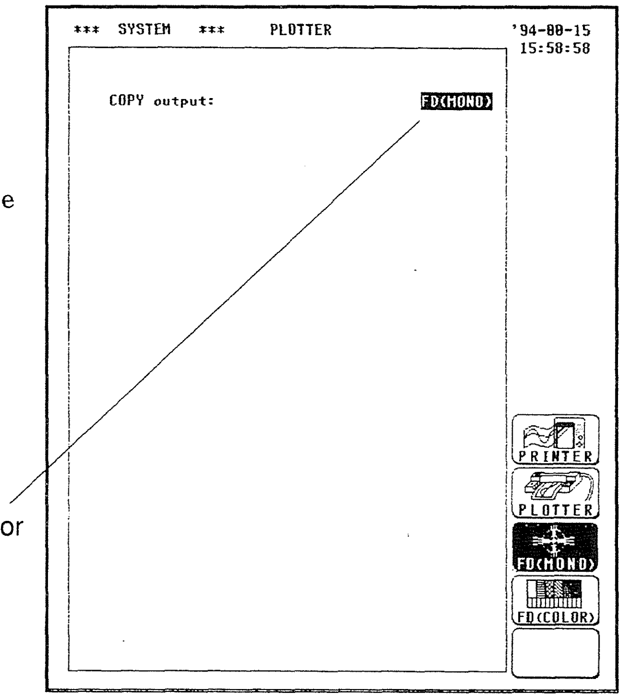
7.1 Saving the Screen Data Function

- The each screen display data of the 8840 can be stored on the floppy disk in the bit map file (BMP) format.
- The bit map file is one of the standard graphic type of the WINDOWS, therefore by using the graphic software, this file format can be used.
- This screen data can be used when making reports by using the software such as a word processor, a tabular calculation, etc..
- By making a following setting and pressing the COPY key, the 480×640 dots screen display data is stored.
- The screen data of the characters and waveforms (light, normal, and dark) colored can be stored.
- The WINDOWS is a registered trademark of Microsoft Corporation.

Method (Screen for making this setting : the SYSTEM screen)

1. Press the SYSTEM key, and the SYSTEM screen will appear.
2. Press the F5 (lof2) key and select F4 (PLOTTER) key.
3. Using the cursor keys, move the flashing cursor to the "COPY output" item.
4. Select according to the function key indications.

Function key indication	*Meaning*
PRINTER	: The direct hard copy of the screen display is printed in the internal unit.
PLOTTER	: The waveform is drawn on the plotter.
FD<MONO>	: Save the display screen data on the floppy disk.(monochrome)
FD<COLOR>	: Save the display screen data on the floppy disk.(color)



*** SYSTEM *** PLOTTER '94-08-15 15:58:58

COPY output: FD<MONO>

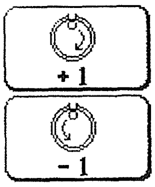
Flashing cursor

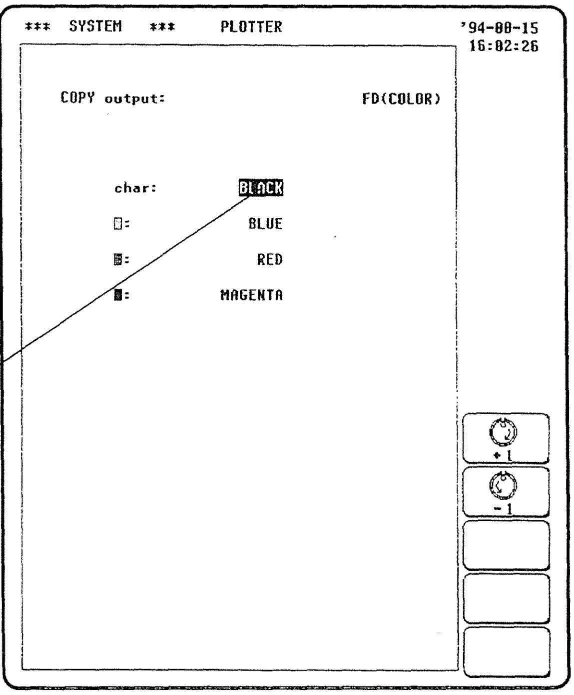
SYSTEM screen

5. If FD(COLOR) is selected in the "COPY output" item, select each color for the character (including frame), waveform (light), waveform (normal), and waveform (dark).

Method (The screen for making this setting: the SYSTEM screen)

6. Move the cursor to each color item.
7. Select using the F1, F2 keys or Jog control.

Function key indication	*Meaning*
	BLACK, BLUE, RED, MAGENTA, GREEN, CYAN, YELLOW, ORANGE



```
*** SYSTEM ***     PLOTTER                         '94-08-15
                                                    16:02:26

  COPY output:                      FD(COLOR)


        char:          BLACK
        □:              BLUE
        ▨:               RED
        ■:           MAGENTA
```

Flashing cursor

SYSTEM screen

8. Press the COPY key, the display screen data is saved on the floppy disk.

Note

- The file name is automatically changed like a "#AUTO×××.BMP" (×××: a three-digit number).
- On the FD screen, the BMP file save function cannot be used.

Appendix

Appendix 1 Table of analysis modes and parameter definitions

Analysis mode	Function definition	Linear real
Storage (time axis data)	fa	fa
Linear spectrum	$Fa = \Im(fa)$ $= \lvert Fa \rvert \cdot \exp(ja)$ $= \lvert Fa \rvert \cdot (\cos\angle a + j\sin\angle a)$	$\lvert Fa \rvert \cdot \cos\angle a$
RMS spectrum	$Ra = \frac{Fa}{\sqrt{2}}$ (Note 1) $= \lvert Ra \rvert \cdot \exp(ja)$ $= \lvert Ra \rvert \cdot (\cos\angle a + j\sin a)$	$\lvert Ra \rvert \cdot \cos\angle a$
Power spectrum	$Gaa = \frac{1}{2} \cdot Fa^{*} \cdot Fa$ (Note 2) $= \frac{1}{2} \cdot \{Re^{2}(Fa) + Im^{2}(Fa)\}$ $= \frac{1}{2} \cdot \lvert Fa \rvert^{2}$	
Auto-correlation function	$Raa(\tau) = \Im^{-1}(Gaa)$ $= \frac{1}{2\pi} \int_{-\infty}^{+\infty} Gaa(\omega) \cdot \exp(j\omega\tau) d\omega$	
Histogram	Pa	
Transfer function	$Hab = \frac{Fb}{Fa} = \frac{Fb \cdot Fa^{*}}{Fa \cdot Fa^{*}} = \frac{Gab}{Gaa}$ (Note 3) $= \frac{\lvert Gab \rvert}{\lvert Gaa \rvert}\{\cos(\angle b - \angle a) + j\sin(\angle b - \angle a)\}$	$\lvert Hab \rvert \cdot \cos(\angle b - \angle a)$
Cross-power spectrum	$Gab = \frac{1}{2} \cdot Fa^{*} \cdot Fb$ $= \frac{1}{2} \cdot \lvert Fa \rvert \cdot \lvert Fb \rvert \{\cos(\angle b - \angle a) + j\sin(\angle b - \angle a)\}$	$\lvert Gab \rvert \cdot \cos(\angle b - \angle a)$
Cross-correlation function	$Rab(\tau) = \Im^{-1}(Gab)$ $= \frac{1}{2\pi} \int_{-\infty}^{+\infty} Gab(\omega) \cdot \exp(j\omega\tau) d\omega$	
Unit-impulse response	$IMP = \Im^{-1}(Hab)$	
Coherence function	$COH = \frac{Gab^{*} \cdot Gab}{Gaa \cdot Gbb}$	
Octave analysis	Oct	

(Note 1) For the DC components, Ra=Fa

(Note 2) For the DC components, $\mathrm{Gaa}=\mathrm{Fa}^{*}\cdot \mathrm{Fa}$

(Note 3) For the DC components, $\mathrm{Gab}=\mathrm{Fa}^{*}\cdot \mathrm{Fb}$

Analysis mode	Linear imaginary	Linear magnitude	Log magnitude	Phase
Storage (time axis data)				
Linear spectrum	$\lvert Fa \rvert \cdot \sin \angle a$	$\lvert Fa \rvert$	$20 \cdot \log \lvert Fa \rvert$	$\angle a$
RMS spectrum	$\lvert Ra \rvert \cdot \sin \angle a$	$\lvert Ra \rvert$	$20 \cdot \log \lvert Ra \rvert$	$\angle a$
Power spectrum		Gaa	$10 \cdot \log(Gaa)$	
Auto-correlation function		Raa		
Histogram		Pa		
Transfer function	$\lvert Hab \rvert \cdot \sin(\angle b - \angle a)$	$\lvert Hab \rvert$	$20 \cdot \log \lvert Hab \rvert$	$\angle b - \angle a$
Cross-power spectrum	$\lvert Gab \rvert \cdot \sin(\angle b - \angle a)$	$\lvert Gab \rvert$	$10 \cdot \log \lvert Gab \rvert$	$\angle b - \angle a$
Cross-correlation function		Rab		
Unit-impulse response		IMP		
Coherence function		COH		
Octave analysis		Oct	$20 \cdot \log(Oct)$	

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