Instruction Manual

B-H Analyzer

SY-8218 / SY-8219

IWATSU ELECTRIC CO., LTD.

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Introduction

◇ Thank you for purchasing this IWATSU and please regularly use IWATSU lastingly in future.
◇ Please read this manual before using this product, then keep the manual handy for future reference.
◇ This instruction manual describes operating precautions, operating procedure, operation examples, and specifications.
◇ In this manual, it explains based on SY-8218. Especially as long as it doesn't refuse, please handle SY-8219 based on it.

Safety Precautions

To ensure safe operation of this product and to prevent injury to the user or damage to property, read and carefully observe the warnings ⚠ and cautions ⚠ in the following sections

Definition of warnings ⚠ and cautions ⚠ used in this manual

⚠ **Warnings**	Incorrect operation or failure to observe the warning may result in death or serious injury.
⚠ **Cautions**	Incorrect operation or failure to observe the caution may result in injury or damage to the instrument.

Notes

◇ Parts of the contents of this manual may be modified without notice for improvements in specifications and functions.
◇ Reproduction or reprinting of the contents of this manual without prior permission from IWATSU is prohibited.
◇ If any question about this product arises, contact Iwatsu at the address listed at the end of this manual or our sales distributors.
◇ Utilities screen of this product shows settings of LAN and GPIB, and remote control option is required to operate the functions.
◇ For options written in this manual, contact our Web homepage or our sales personnel.

History

◇ May 2011: 1st edition
◇ November 2011: 2nd edition
◇ May 2012: 3rd edition
◇ July 2013: 4th edition
◇ January 2014: 5th edition
◇ July 2015: 6th edition
◇ September 2015: 7th edition
◇ May 2016: 8th edition
◇ Aug 2016: 10th edition
◇ Jun 2017: 11th edition

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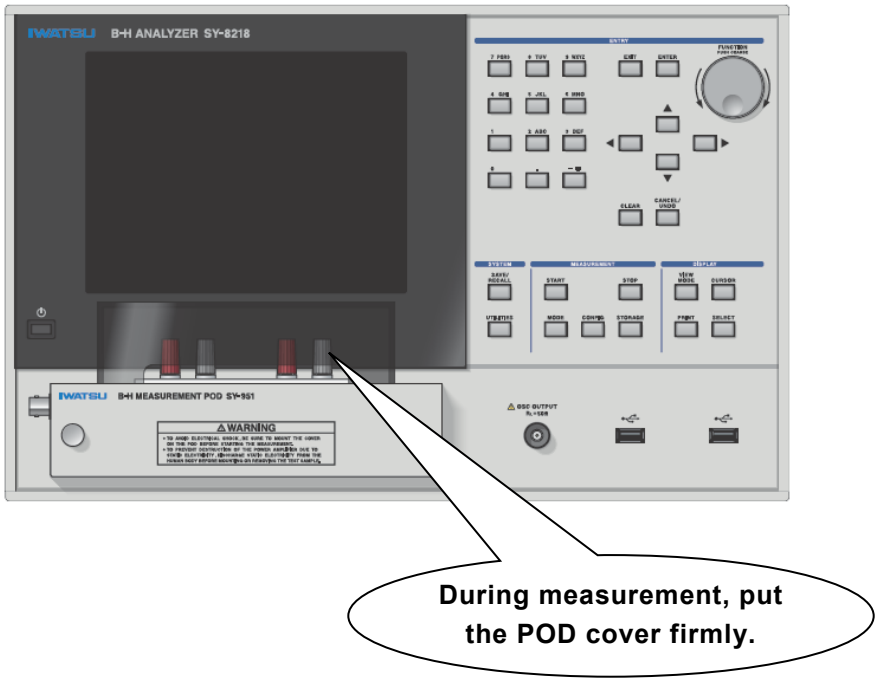
Read the following safety information.

Read the next page.

⚠ Warnings

- **Do not touch the measurement POD terminal during excitation.**
  Touching it during excitation may result in an electric shock.
  During measurement, put the POD cover on the POD.
  This product may be used in combination with an external power amplifier (optional).
  The maximum voltage and current of the exciting power amplifier may be applied to the POD terminal which is connected to a sample.
  To prevent danger, put the provided POD cover on the POD before starting measurement.
  If it is detected that the POD cover is not mounted, the supply of the exciting current is immediately shut down to stop the power supplied to the sample.



- **Do not use in an environment with explosive gases.**
  It may cause an explosion.

Read the following safety information. Read the next page.

⚠ Warnings (Continued)

- **If you notice smoke, foul odor or abnormal noise, immediately power off this product and remove the power plug from the receptacle.**

  Continued use under these circumstances may result in an electric shock or fire. Set the power switch on the front to STANDBY, turn off the main switch on the rear, and remove the power plug from the receptacle, and then contact Iwatsu office or our sales distributors for repair. Do not attempt to repair this product yourself.

- **Make sure no water gets on or inside this product.**

  Do not use this product if wet, otherwise an electric shock or fire could occur. If water gets on or inside this product, set the power switch on the front to STANDBY, turn off the main switch on the rear, and remove the power plug from the receptacle, and then contact Iwatsu office or our sales distributors for repair.

- **Do not place this product on an unstable support such as shaky base or inclined plane.**

  Dropping or falling-down of this product could result in an electric shock, injury, or fire. If this product is dropped or its cover is broken, set the power switch on the front to STANDBY, turn off the main switch on the rear, and remove the power plug from the receptacle, and then contact Iwatsu office or our sales distributors for repair.

- **Do not expose this product to excessive vibration or shock.**

  Dropping of falling-down of this product could result in injury.

- **Dropping of this product could result in injury to your body or damage to your property.**

  When carrying this product, remove the measurement POD and cables and hold it by grasping the center of the handle in two places with both hands firmly so that it should not drop.

- **Use 3-core power cord.**

  If not, an electric shock or fire may occur.
  - If power is supplied from the 2-wire receptacle using the 3-core/2-core conversion adapter, connect the ground terminal of the 3-core/2-core conversion adapter to the ground.
  - If power is supplied from the 3-wire receptacle using the provided 3-core power cord, grounding is made by the ground line of the power cord.

Read the following safety information. Read the next page.

⚠ Warnings (Continued)

- **Always use this product with a specified power supply voltage.**

  If not, an electric shock, fire, or failure may occur. The range of operating voltage to be used is stated on the rear panel.
  This product runs on AC power supply of single-phase, 50/60Hz and AC100-240V.
  No voltage selection is required, since this product automatically adapts to the power supply voltage.

- **Strictly observe items below when handling the power cord.**

  If not, an electric shock or fire may occur. If the power cord is damaged, contact Iwatsu office or our sales distributors for repair.

  - Do not modify the power cord.
  - Do not forcibly bend the power cord.
  - Do not twist the power cord.
  - Do not bundle the power cord.
  - Do not pull the power cord.
  - Do not heat the power cord.
  - Do not let the power cord get wet.
  - Do not put heavy objects on the power cord.

- **Do not touch the plug of the power cord with wet hands.**

  If not, an electric shock may occur.

- **Do not make metal touch the blade of the power plug.**

  If not, an electric shock or fire may occur.

- **Do not plug too many leads into a single receptacle.**

  If not, a fire or overheating may occur.

- **If thunder sounds, remove the power plug of this product from the receptacle and do not use it.**

  If not, a fire or electric shock may occur.

- **Do not remove the operation panel.**

  Since a high-voltage part exists inside, touching it may result in an electric shock. When inspecting or calibrating this product, contact Iwatsu office or our sales distributors.

Read the following safety information. Read the next page.

⚠ Warnings (Continued)

- **Do not modify this product.**
  Modification of it could result in an electric shock, fire, or failure.
  In this product, the open security seal (Refer to the drawing for X page and "Repair and return of repaired product") is pasted to main unit and measurement POD. It is not possible to respond to the repair when the open security seal is peeled off, and remodeled.

- **Do not use this product when being failed.**
  If not, an electric shock or fire may occur. For a failure, contact Iwatsu office or our sales distributors for repair.

- **Do not put any metallic material or inflammable object through the ventilation port.**
  If any foreign object is put through the ventilation port, an electric shock, fire, or failure may occur. If any foreign object enters this product, set the power switch on the front to STANDBY, turn off the main switch on the rear, and remove the power plug from the receptacle, and then contact Iwatsu office or our sales distributors for repair.

- **Do not put any object near to the exhaust port or ventilation port of this product.**
  If not, heat accumulates inside this product, causing an electric shock, fire, or failure.

- **Before inserting the power plug into the receptacle, confirm no dust attached to it. In addition, remove the power plug and adapter from the receptacle and inspect/clean them once a half year or a year.**
  Dust may cause an electric shock, fire, or failure.

Read the following safety information.

Read the next page.

⚠ Cautions

- **Set the power switch on the front to STANDBY, turn off the main switch on the rear before connecting or disconnecting the power cord.**
  Connecting or disconnecting the power cord while the power switch is ON may result in an electric shock or failure.

- **Insert the power supply plug into the receptacle firmly.**
  If not, an electric shock, fire, or failure may occur.

- **When disconnecting the power cord from the receptacle, pull it out by grasping the plug.**
  Do not pull on the cord itself, as doing so may damage the cord and could result in an electric shock or fire.

- **Before moving this product, confirm that external connection lines such as the power cord and cables are removed.**
  The power cord and cable may be damaged causing a fire or electric shock.

- **Never replace the fuse inside the main unit. Contact Iwatsu office or our sales distributors for replacement.**

- **Use 3-core power cord in accordance with the power supply voltage.**
  If not, a fire may occur. In addition, if a 2-core power cord is used, a fire may occur.
  Unless specified when purchasing this product, the power cord suitable for 100V system (center voltage: 100V to 120V) is attached. If the power supply voltage is 200V system (center voltage: 200V to 240V), use 3-core power cord suitable for 200V system (optional) specified by Iwatsu (rating voltage: 250V).

- **Do not apply an excessive voltage or current to the input connector (POWER INPUT of the measurement POD).**
  If not, a fire, electric shock, damage to this product or a sample, or failure may occur.
  The maximum allowable input voltage or current are as follows:

Input connector	Maximum allowable input voltage or current
Between P2-P1	±200V
Between S2-S1	±200V
POWER INPUT(SY-951 / SY-955)	±6A

(For details, see Chapter 8 ■Signal Detection Part in Instruction Manual PDF data on the CD.)

- **Do not ground the output connector or apply a voltage to the output connector.**
  Grounding it or applying a voltage to it may damage the ICs.

- **Please check the sample parameters and the measurement conditions beforehand before starting the measurement.**
  If you measure with incorrect sample parameters and measurement conditions, excessive current will flow through the sample and the temperature of the core and windings may rise.
  It may lead to deterioration of the core or burning of the windings. Also, exceeding the rated output of the power amplifier may result in failure of the power amplifier or failure of this product.

Read the following safety information.

⚠ Cautions (Continued)

● **Do not place any object on this product.**
Otherwise, the cover may contact the internal circuits causing an electric shock, fire, or failure.

● **Always use this product only within the rated operating range.**
If used over the rated range, failure may occur. The allowable range is as follows:
- Only indoor use
- Temperature: +5°C to +35°C
- Humidity: 85 % RH (+35°C, non-condensation)

● **Do not expose this product to direct sunlight or high humidity.**
If not, heat may accumulate inside this product, resulting in a fire.

● **Do not place this product in a location with excessive moisture or dust.**
If not, an electric shock or fire may occur.

● **Do not expose this product to oil smoke or steam; e.g. besides cooking table or humidifier.**
A fire or electric shock may occur.

● **Do not use any damaged cable or adaptor.**
Otherwise, an electric shock or fire may occur.

● **If this product will not be used for a long time, remove the power plug from the receptacle for safety.**

● **When transporting this product, remove the measurement POD from the main unit and use the packing material provided at the time of purchase or packing material equivalent at least.**
Excessive vibration or shock applied to this product during transportation may cause it to malfunction, resulting in a fire. The case where a failure or damage occurs when transporting this product with the measurement POD attached to the main unit **shall not be guaranteed.**
If there is not a proper packing material/ shock absorber, contact Iwatsu office or our sales distributors. When having this product transported by a shipping company, write "Precision Instrument - Handle With Care" on each side of the packing box.

● **When cleaning this product, remove the power plug from the receptacle for safety. Use dry cloth to wipe water drops away.**
If not, an electric shock or fire may occur.

● **When turning on the switch on the rear of this product, a low frequency sound may be generated. It does not affect characteristics and the life at all.**
It is caused by a low frequency vibration in transition of chock coil for high-frequency measures.

● **This instrument is an equipment of Class A (Industrial electromagnetic environment). There may be a difficult possibility about keeping the electromagnetic compatibility in environments other than industrial due to conducted as well as radiated disturbances. Avoid use in the residential areas, except when you do measures to which the user decreases the electromagnetic emissions to prevent interference because there is a possibility to cause interference for other equipment.**

Checking packed materials

When receiving this product, check the packed materials referring to components below (for the open bale chart, see the next page). If there is a lacked item or an item damaged during transportation, immediately contact Iwatsu office or our sales distributors.

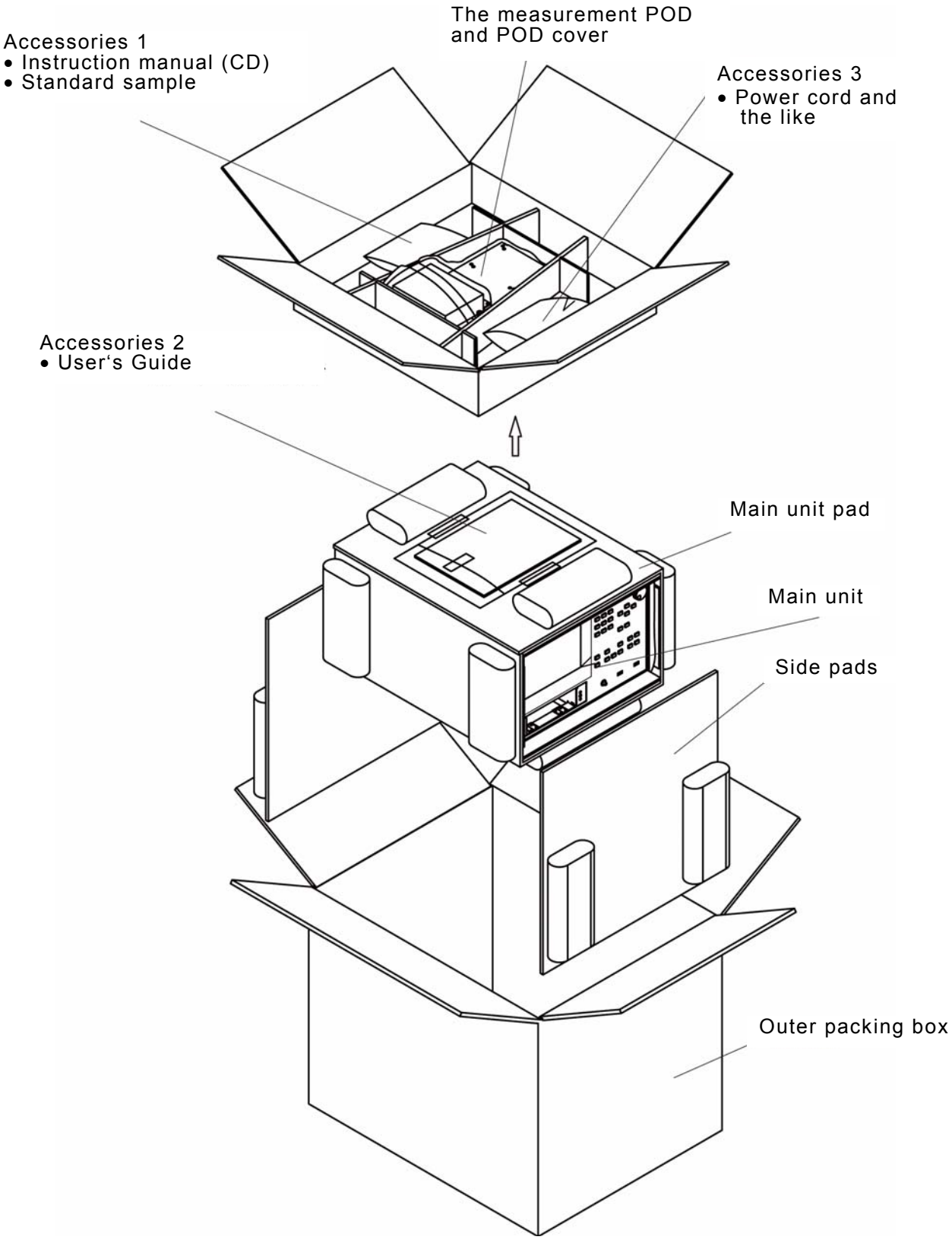
Components

B-H Analyzer main unit 1
Standard Measurement POD 1
Accessories
- Power cord 1
- Cord strap 1
- POD cover.....1
- AC couple module 1
- Power amplifier cable (BNC-BNC).....1
- OSC cable (BNC-SMA).....1
- Standard sample (TYPE A).....1
- Instruction manual (CD).....1
- User's guide 1

［**Information**］

In our inspection process, rubbing that has adhered to the heaven side and the bottom of measurement POD cannot evade constructional.
There must not be influence on the performance, and please agree and put it.

Open bale chart (main unit and accessories)



Management of product

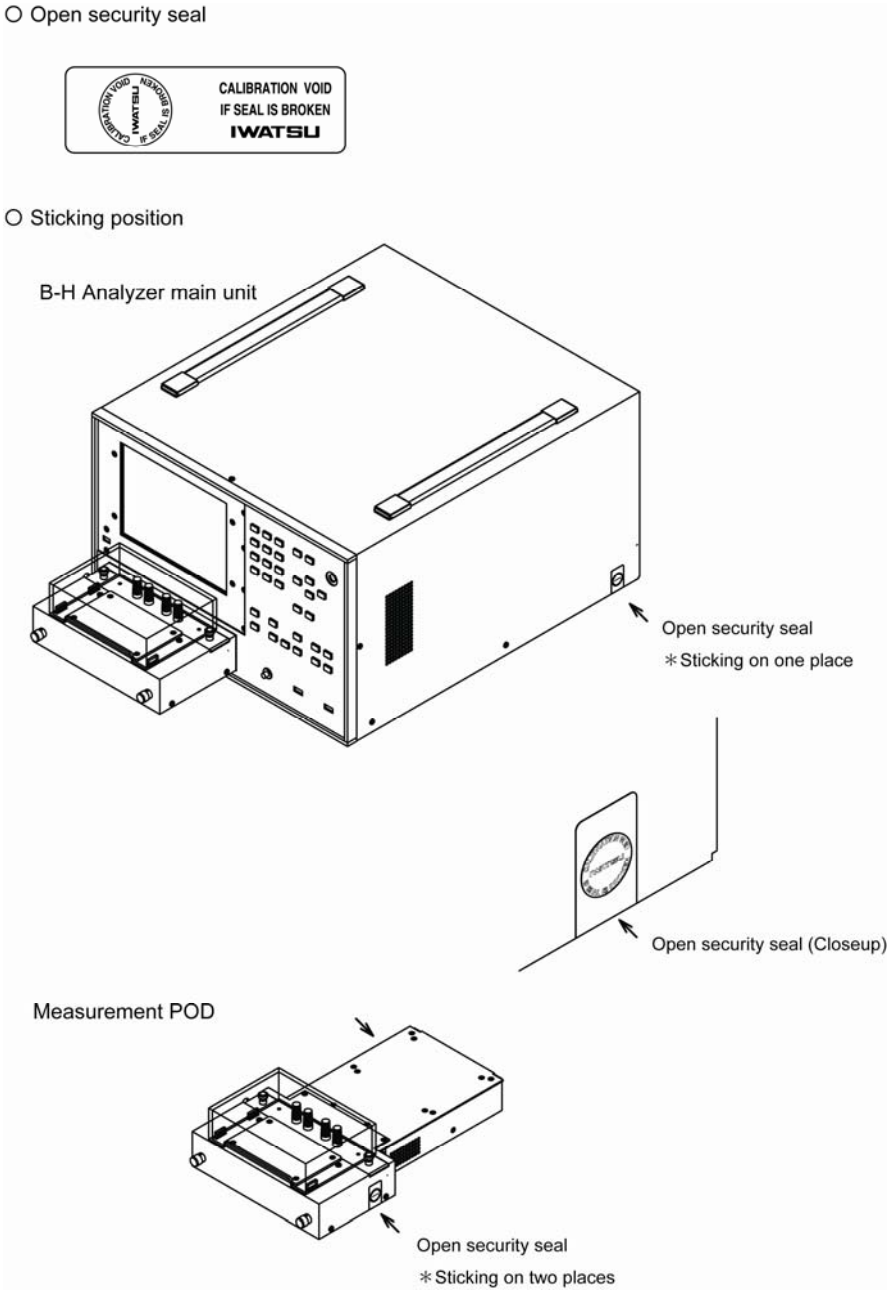
When disposing of this product, it is necessary to recycle or dispose of it properly in accordance with a local law or regulation. When disposing of it, request a recycle company to dispose of it in accordance with a local law or regulation

Repair and sending of repaired product

If a failure occurs, return this product to our service center. Any failure which occurs in the term of guarantee and for which Iwatsu is responsible should be repaired without any cost.
When sending a product to be repaired, clearly write the product name, serial number (in the label on the rear of this product), and description of the failure, name, division, and telephone number of responsible person.

About the open security seal

In this product, the open security seal is pasted to main unit (one place) and measurement POD (two places) as shown in the figure below. In this product, the open security seal is pasted to main unit (one place) and measurement POD (two places) as shown in the figure below. Please note not responding to the repair when the open security seal is removed.



Contents

Chapter 1 Before Getting Start

■ 1.1 Features

- This product is this product to measure various types of physical amount of soft magnetic materials. It is equipped with the signal generator which can generate both a sine wave and a square wave, excites a sample while automatically increasing a magnetic field value or a magnetic flux density value gradually until they reach a specified value. When the value is reached, it starts measurement. In addition, not to leave any residual magnetization in a sample after measurement, it reduces magnetization by automatically applying an attenuation alternating magnetic field.

  This product has also features below:

  ■ By reviewing a sample for a calibration standard, it can make more accurate and more stable measurement than the Iwatsu existing product for core loss and the like

  ■ Since the number of pieces of obtained waveform data is 8,192 points/ cycle; i.e. 16 times as many as the Iwatsu existing product, it can measure coercive force, residual magnetic flux density and the like with high accuracy.

  ■ It can execute not only sine wave excitation but also pulse excitation (max.: 1 MHz, Duty 50 %, symmetry).

  ■ Because of Reference function installed, it can compare B-H hysteresis loops which are measured under two different measurement conditions.

  ■ Because of two types of cursor measurement functions (Cross and Grad) installed, it can display a measurement value and permeability at an arbitrary point

  ■ Measurement data and measurement conditions can be stored in the CSV format with punctuation using tabs and screen hard copy can be stored in a USB memory in JPEG or PNG format.

  ■ Measurement data and measurement conditions stored in a USB memory can be recalled to draw the stored data again and to make settings.

  ■ It has the function to storage setting conditions before powering off and when it starts next time, it uses them.

■ 1.2 Cautions for installation

- Use this product within a specified range of temperature and humidity.
  If exposed to direct sunlight or used outside an operating range; e.g. high humidity, it may fail.
  Ranges of temperature and humidity for usage are as follows:

  ■ Only indoor use
  ■ Temperature: +5 °C to +35 °C (operation guaranteed range)
  ■ Humidity: 85 % RH (+35 °C, non-condensation, operation guaranteed range)

- Do not place this product in a location with excessive moisture or dust.
  Otherwise, electric shock or fire may occur.

- Do not place an object on this product.
  If an object is placed on this product, the cover may contact the internal circuit, resulting in electric shock, fire, or failure.

- Do not place an object near to the exhaust port or ventilation port of this product.
  Otherwise, heat may accumulate inside this product, resulting in electric shock, fire, or failure.

- If this product falls, its impact may cause your body or property to be damaged. When carrying it, remove the measurement POD and cables and hold it by grasping the handle in two places at the center with both hands securely so that it does not fall.

■ 1.3 Cautions for transportation

- When transporting this product, remove the measurement POD from the main unit and use the packing material attached at the time of purchase or equivalent.
  The case where a failure or damage occurs when transporting this product with the measurement POD attached to the main unit **shall not be guaranteed**.

- Remove the measurement POD as follows:

  ① Loose two clamp knobs on the front of the measurement POD by rotating them counterclockwise.

  ② Apply both hands on both sides of the measurement POD and pull the measurement POD to your side horizontally along the guide rails.
  * Never use excessive power to pull it; otherwise, the measurement POD or guide rails may be damaged.

- Installation of the measurement POD is done in the reverse procedure of removing it, as follows:

  ① Apply both hands on both sides of the measurement POD and insert it in the POD installation opening of the main unit, and press it along the guide rails to the bottom.
  * Never use excessive power to install it; otherwise, the measurement POD or guide rails may be damaged.

  ② Install the measurement POD by clockwise rotating two clamp knobs on the front

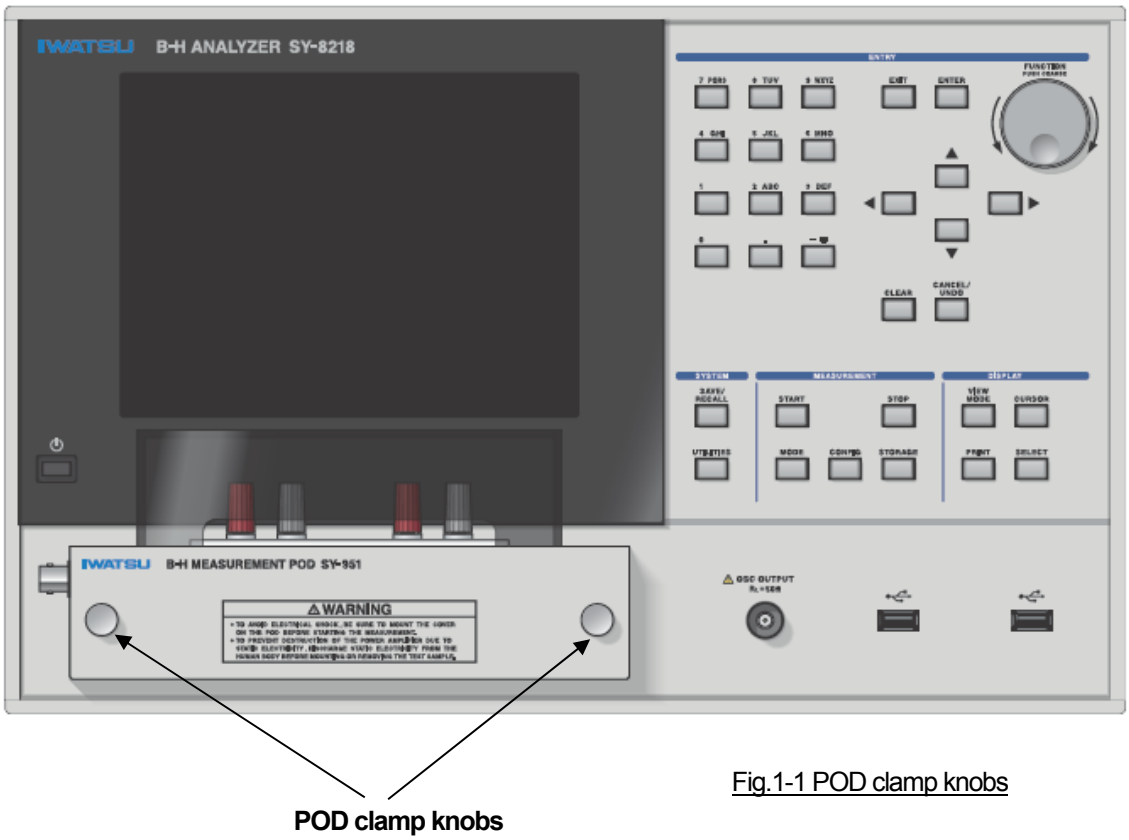


Fig.1-1 POD clamp knobs

■ 1.4 About Windows Embedded

- This product uses **Windows Embedded Standard** as the operating system but it **is not disclosed to a customer**. If behaviors below cause a failure or damage, this product **shall not be guaranteed and repaired**.

  ■ Never connect a keyboard or a mouse to the USB port of this product; i.e. operation is not guaranteed.

  ■ Never connect other than a USB memory and options specified by Iwatsu to the USB port of this product; i.e. operation is not guaranteed.

  ■ Never insert any customer's file in C or D drive of this product using an illegal method or never install your application software.

Chapter 2 Measurement Principle

■ 2.1 Basic measurement principle

N_1: No. of primary turns
N_2: No. of secondary turns
Ae: Effective net core area
Le: Effective length of magnetic path
Ve: Effective volume

- The basic measurement principle used by this product to obtain a magnetic field strength H and a magnetic flux density B generating in a sample to be measured is explained using the 2-coil method.

Fig.2-1 shows a measured sample to which the primary turns are applied for excitation (No. of turns: N_1) and the secondary turns are applied for detecting the magnetic flux density (No. of turns: N_2). Fig.2-2 shows the diagram outlining a measured sample connected to this product using the optional power amplifier.

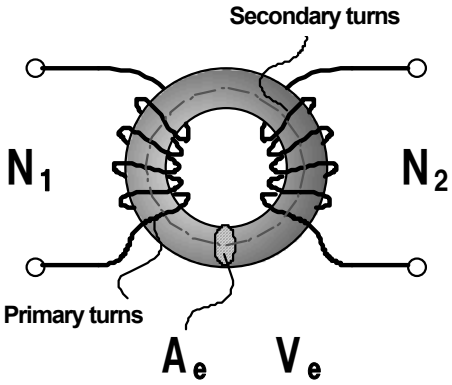


Fig.2-1 Shape of sample

The signal generator built in this product generates an excitation signal and the power amplifier amplifies the signal, allowing the exciting current $i_1(t)$ to flow through the primary turns.

The exciting signal i_1 (t) is converted into a voltage Vs (t) by the shunt resistor with a resistance value of Rs built in this product.

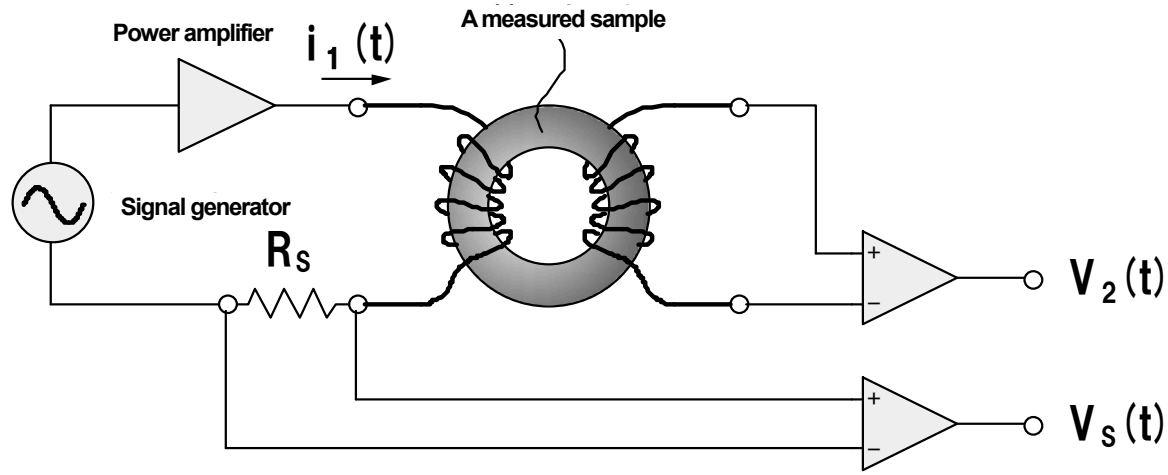


Fig.2-2 Diagram outlining a measured sample connecting to this product

Therefore, the magnetic field strength H (t) generating in the measured sample can be obtained using:

$$H(t)=\frac{N_1\cdot i_1(t)}{L_e}=\frac{N_1\cdot V_s(t)}{L_e\cdot R_s} \qquad (2.1)$$

An induced voltage V_2 (t) is also generated between both sides of the secondary turns. Therefore, the magnetic flux density B (t) in the measured sample can be obtained using:

$$B(t)=\frac{1}{N_2\cdot A_e}\int_0^t V_2(\tau)d\tau \qquad (2.2)$$

■ 2.2 Expressions to calculate measurement values

● The following is explanation of expressions to calculate values measured by this product.

This product uses two measurement modes of Normal mode and μ mode, and Table 2-1 shows measurement values displayed in each calculation mode.

The calculation difference point of Normal mode and μ mode is the following. In μ mode, the complex permeability from fundamental wave element of intensity of the magnetic field H and magnetic flux density B is calculated. In Normal mode, the value which is not calculated by using them is calculated. Refer to the following expressions for details

Table 2-1 Calculation modes and measurement values

* Units in [ ] are typical. The symbol to which * adheres is calculated from the fundamental wave element.

Calculation modes	Normal mode			μ mode		
	Symbol	Typical unit	Meaning	Symbol	Typical unit	Meaning
Measurement values	Pcv	[W/m^3]	Core loss per volume	Bm	[T]	Max. magnetic flux density
	Pcm	[W/kg]	Core loss per mass	V_2m	[V]	Max. induced voltage
	θ	[deg]	Phase angle	Hm	[A/m]	Max. magnetic field
	μ_a	—	Relative permeability	I_1m	[A]	Max. exciting current
	Bm	[T]	Max. magnetic flux density	μ_a	—	Relative permeability
	V_2m	[V]	Max. induced voltage	*L	[H]	Inductance
	Br	[T]	Residual magnetic flux density	*R	[Ω]	Resistance
	Hm	[A/m]	Max. magnetic field	*|Z|	[Ω]	Impedance
	Hc	[A/m]	Coercive force	Pc	[W]	Core loss
	Pc	[W]	Core loss	*μ′	—	Complex permeability (real part)
	VA	[VA]	Apparent power	*μ″	—	Complex permeability (imaginary part)
	I_1m	[A]	Max. exciting current	*μ_z	—	Impedance permeability
	Br/Bm	—	Rectangular ratio	*θ	[deg]	Phase angle
	2Φm	[Wb]	Total flux linkage	*Q	—	Quality coefficient
	—	—	—	*tanδ	—	Loss coefficient
	—	—	—	THD	[dB]	Total harmonic distortion

Expressions used by this product to calculate each value shown in Table 2-1 are as follows:

■ Hm, Hc, Bm, Br, μ_a, Br/Bm, 2Φm
For symbols, see Figure 2-3.

$$H_m = \frac{\left|H_m \uparrow\right| + \left|H_m \downarrow\right|}{2} \quad (2.3)$$

$$B_m = \frac{\left|B_m \uparrow\right| + \left|B_m \downarrow\right|}{2} \quad (2.4)$$

$$H_c = \frac{\left|H_c \uparrow\right| + \left|H_c \downarrow\right|}{2} \quad (2.5)$$

$$B_r = \frac{\left|B_r \uparrow\right| + \left|B_r \downarrow\right|}{2} \quad (2.6)$$

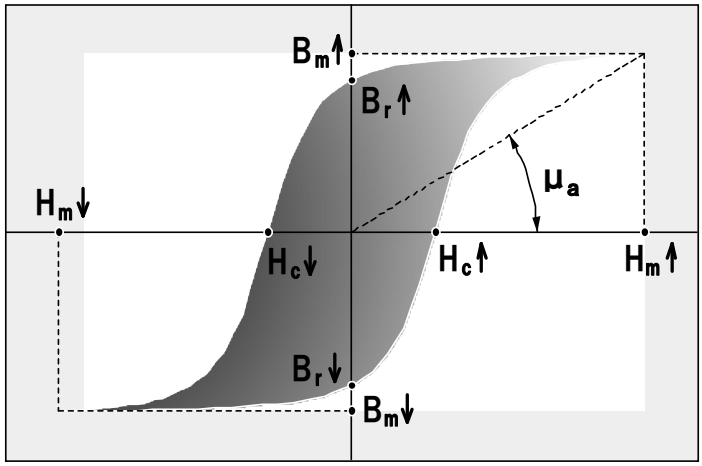


Fig.2-3 Hm, Hc, Bm, Br, μa

$$\mu_a = \frac{B_m}{\mu_0 H_m} \qquad (2.7)$$

(μ_0: Vacuum permeability $4\pi \times 10^{-7}$[H/m])

$$B_r / B_m = \frac{B_r}{B_m} \qquad (2.8)$$

$$2\phi_m = A_e\left(B_m \uparrow - B_m \downarrow\right) \qquad (2.9)$$

$$P_c = \frac{N_1}{N_2} \cdot \frac{1}{T} \cdot \int_0^T i_1(t) \cdot V_2(t)\, dt \qquad (2.10)$$

$$P_{cv} = \frac{P_c}{V_e} \qquad (2.11)$$

$$P_{cm} = \frac{P_c}{W_e} \qquad (2.12)$$

$$VA = \frac{N_1}{N_2} \cdot i_{1RMS}(t) \cdot V_{2RMS}(t) \qquad (2.13)$$

(RMS: Effective value)

Normal mode

$$\theta = \cos^{-1}\left(\frac{P_c}{VA}\right) \qquad (2.14)$$

* The θ of μ mode is calculated by the expression (2.17).

$$\mu = \mu' - j\,\mu'' = \frac{B(\omega_0)}{\mu_0 H(\omega_0)} \qquad (2.15)$$

(μ: Complex permeability, j: imaginary unit, $\omega_0 = 2\pi f_0$, f_0: measurement frequency)

$$\mu_z = \sqrt{(\mu')^2 + (\mu'')^2} \qquad (2.16)$$

μ mode

$$\theta = \cos^{-1}\left\{\frac{P_c(\omega_0)}{VA(\omega_0)}\right\} \qquad (2.17)$$

$$Q = \frac{\mu'}{\mu''} \qquad (2.18)$$

$$\tan\delta = \frac{1}{Q} \qquad (2.19)$$

$$L = \frac{\mu'\,\mu_0\,A_e\,N_1^2}{L_e} \qquad (2.20)$$

$$R = \frac{\omega_0 \, \mu'' \, \mu_0 \, A_e \, N_1^2}{L_e} \tag{2.21}$$

$$|Z| = \sqrt{R^2 + (\omega_0 \, L)^2} \tag{2.22}$$

$$THD = 20 \log_{10} \frac{\sqrt{V_2^2(3\omega_0) + V_2^2(5\omega_0) + V_2^2(7\omega_0)}}{V_2(\omega_0)} \tag{2.23}$$

Chapter 3 Names and Functions of Each Part

■ 3.1 Front panel

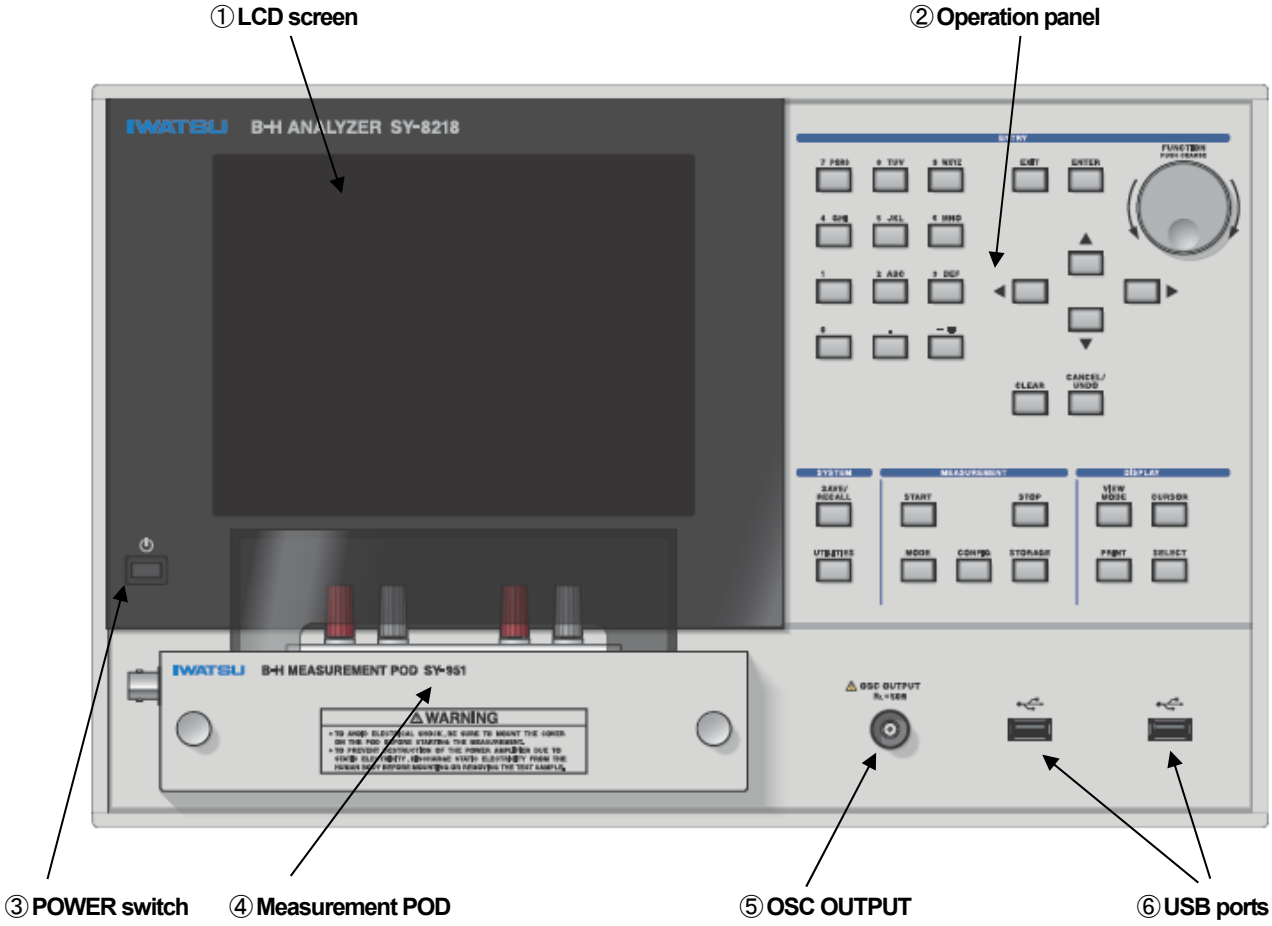


Fig. 3-1 Front panel

① **LCD screen** It displays a measurement screen of this product.

② **Operation panel** It includes operation buttons and the like of this product.

③ **POWER switch** It starts/ stops this product.
* **Only when Main power switch on the rear is turned on, it is effective.**

④ **Measurement POD** It connects a sample to be measured (the standard POD for SY-8218: SY-951, the standard POD for SY-8219: SY-955).

⑤ **OSC OUTOUT** It is the output terminal of the built-in signal generator.

⑥ **USB ports** It connects a USB memory to save/ recall measurement data and setting conditions.
* There are five USB ports; two on the front and three on the rear. Every USB port can be used. They are assigned characters of driver in order of attachment timing (first E, next F, G, H, and finally I) in the same manner as a computer.

■ 3.2 Rear panel

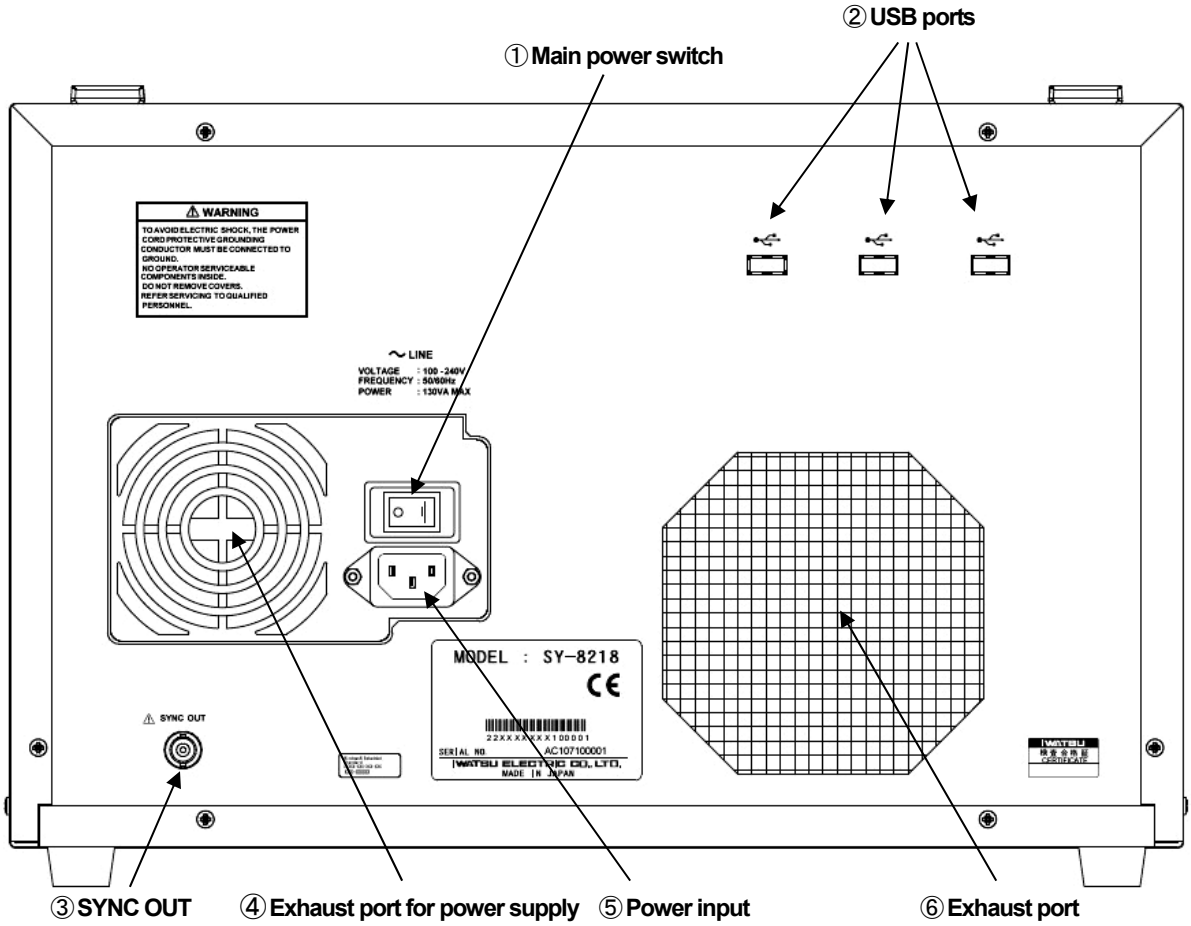


Fig.3-2 Rear panel

① **Main power switch**	It powers on/ off this product; **I** position: on, .**O** position: off.
② **USB ports**	It connects a USB memory to save/ recall measurement data and setting conditions. * There are five USB ports; two on the front and three on the rear. Every USB port can be used. They are assigned characters of driver in order of attachment timing (first E, next F, G, H, and finally I) in the same manner as a computer.
③ **SYNC OUT**	It generates a synchronous signal of the built-in signal generator; i.e. expansion terminal for options other than this function.
④ **Exhaust port for power supply**	It is the air forcibly cooled exhaust port for power supply.
⑤ **Power input**	It is the AC power input connecting the provided power cord.
⑥ **Exhaust port**	It is the air forcibly cooled exhaust port of this product.

■ 3.3 Operation panel

● Functions of the operation panel are as follows:

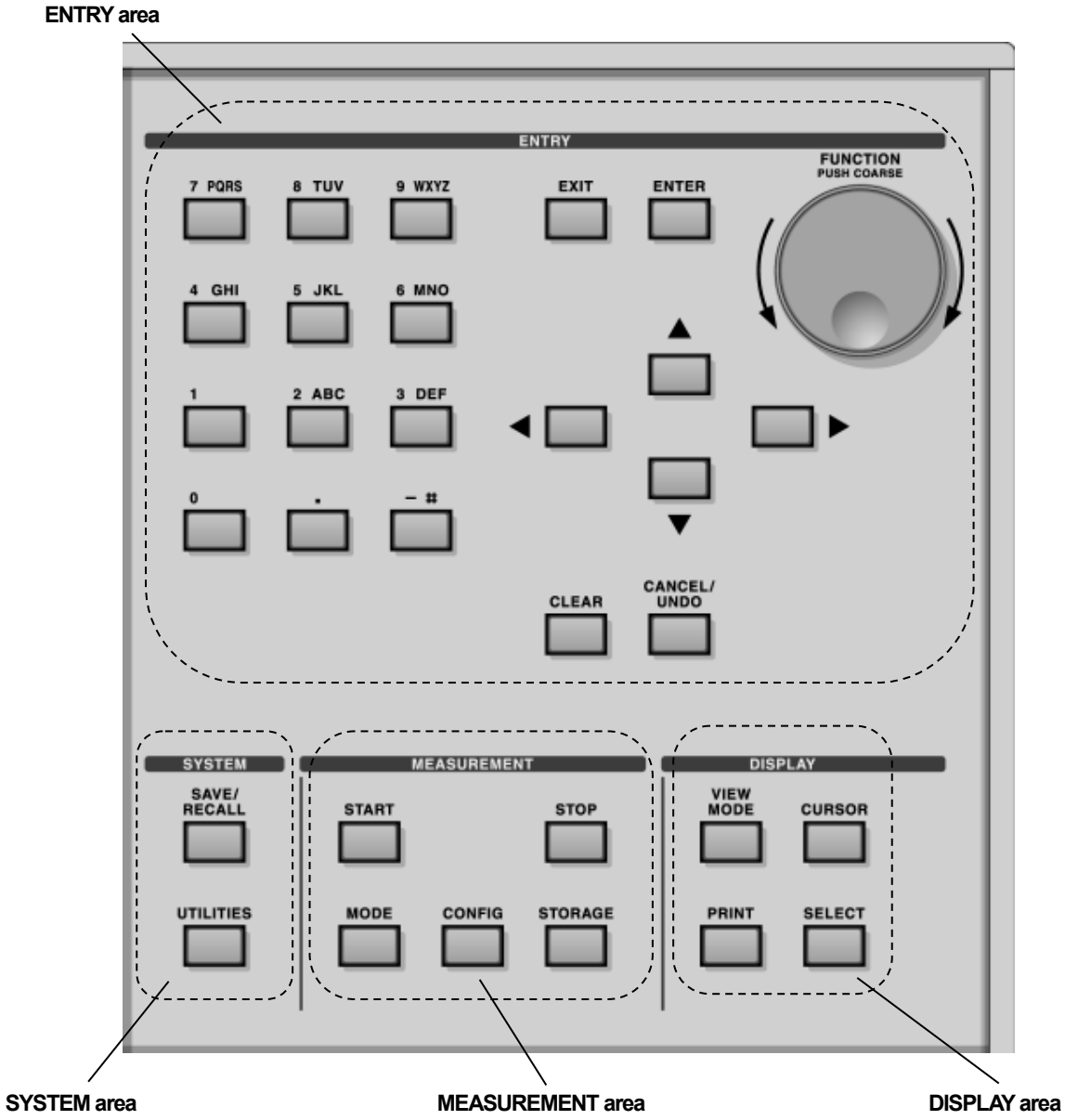
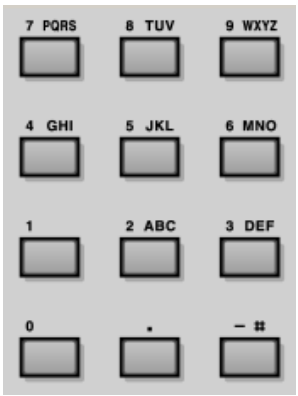


Fig.3-3 Operation panel

■ 3.3.1 ENTRY area

[Ten keys]



- It displays number keys (0 - 9), character keys (upper, lower cases), symbols (., -, #), space.
- For a key on which several characters are written, a displayed character changes each time it is pressed.

[Ex.] 

Each time pressed, a displayed character changes as follows:

7 → P → Q → R → S → p → q → r → s → 7 → P …

* On Edit box into which only numeric value can be entered, characters, -, #, and space cannot be displayed.
* **-/ # key** changes only among -, #, and space.

[ENTER key]

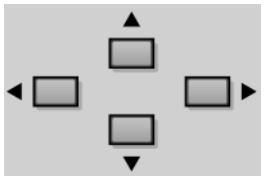
- Popup Edit Box: It determines an alphanumeric character to be entered in the box.
- Popup List:: It determines an item to be selected from the list.
- Measurement screen: It determines a position to be changed and allows the position to pop up.

[EXIT key】

- It closes Popup Edit Box and Popup List.
- It closes Utilities screen and Configuration screen.

* If .Popup Edit Box is closed during input operation, the settings just before closing should be kept.

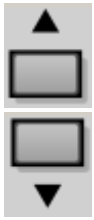
[Arrow keys]



- On Popup Edit Box input:

The edition cursor moves to the **right** by one character.

The edition cursor moves to the **left** by one character.



A current character displayed on the edition cursor changes as follow:
Character: A → B … Y → Z → a → b … y → z → A …
Number: 1 → 2 … 9 → 0 → 1 …
A current character displayed on the edition cursor changes as follow:
Character: A → z … b → a → Z → Y … B → A …
Number: 1 → 0 … 3 → 2 → 1 …

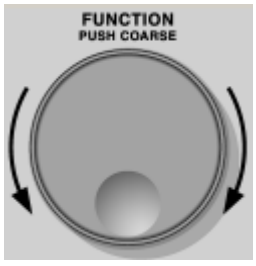
- On Popup List display:

The edition cursor moves **upward** by one line.

The edition cursor moves **downward** by one line.

- On measurement screen, Utilities screen, Configuration screen: The edition cursor moves in the direction of the key.

[Function knob]



- On Popup Edit Box:

Clockwise rotation allows a current character displayed on the edition cursor to change as follows:
Character: A → B … Y → Z → a → b … y → z → A …
Number: 1 → 2 … 9 → 0 → 1 …
Counterclockwise rotation allows a current character displayed on the edition cursor to change as follows:
Character: A → z … b → a → Z → Y … B → A …
Number: 1 → 0 … 3 → 2 → 1 …

- On Popup List: **Clockwise rotation** allows the edition cursor to move **downward**.
  Counterclockwise rotation allows the edition cursor to move **upward**.
- On measurement screen, Utilities screen, Configuration screen: The edition cursor moves
  (For details on the cursor below. see "6.7 Cursor measurement")
- Cursor display (B-H graph): **Clockwise rotation** allows the cursor to move in the **direction of time going forward**.
  Counterclockwise rotation allows the cursor to move in the **direction of time going backward**
- Grad cursor display (B-H graph): **Clockwise rotation** allows the cursor to move **clockwise**.
  Counterclockwise rotation allows the cursor to move **counterclockwise**.
- Vertical cursor display (time axis graph): **Clockwise rotation** allows the cursor to move to the **right.**
  Counterclockwise rotation allows the cursor to move to the **left**.
- Cursor display: Pressing it allows cursor movement to toggle between Coarse (unit of 20points) and Fine.

[CLEAR key]

- Popup Edit Box allowing character input : It **clears** characters in the box.
- Popup Edit Box allowing only number input : It sets a number in the box to **0**.

[CANCEL/ UNDO key]

- Edit Box selection : Pressing it allows items in the box to toggle between old settings/ current settings.
- Popup Edit Box input : It cancels an entry and closes Popup Edit Box.
- List Box selection : Pressing it allows items in the box to toggle between old settings/ current settings.
- Popup List display : It cancels a selected item and closes Popup List.

* When a Reference measurement value appears, UNDO does not function.

■ 3.3.2 SYSTEM area

[SAVE/RECALL key]

- Selection of SAVE/RECALL allows Popup List to appear.
- If pressed when Popup List is displayed, Popup List is closed.

[UTILITIES key]

- It displays Utilities screen.
- If pressed when Utilities screen is displayed, the screen is closed.
  * The screen can also be closed by pressing EXIT key.

■ 3.3.3 MEASUREMENT area

[START key]

- It starts measurement.

[STOP key]

- If pressed during measurement, the measurement is forcibly stopped.

[MODE key]

- It displays Popup List to select a measurement mode.
- If pressed when Popup List appears, the list is closed.

[CONFIG key]

- It displays Configuration screen.
- If pressed when Configuration screen appears, the screen is closed.
  * The screen can also be closed by pressing EXIT key.

[STORAGE key]

- It memorizes Current waveform displayed in **yellow** after measurement as Ref. (Reference) waveform.
  * If there has already been Reference waveform, it is overwritten.

■ 3.3.4 DISPLAY area

[VIEW MODE key]

- Each time pressed in a measurement screen, a displayed graph is changed to a time axis graph/ B-H graph.

[CURSOR key]

- It displays Popup List to select a measurement cursor.
- If pressed when Popup List appears, the edition cursor moves **downward**. If this state is kept for approx. 3 seconds, selection of an item on the edition cursor is determined and Popup List closes automatically.

[PRINT key]

- A copy on the measurement screen is generated to a specified output destination in a specified file format.
  * The file format and output destination are specified in Print frame on Utilities screen (for details, see "■ 5.3 Setting of Print").

[SELECT key]

- If Reference waveform is memorized on the measurement screen, each press of it allows Current/ Ref. waveforms to be displayed or not as follows: (For details, see "■ 6.9 Reference function".)

Table 3-1 Function of SELECT key

[Explanatory note] ●: display —: not display

Operation	Display graph		Cursor measuring object		Meas. condition		Meas. value	
	Current	Ref.	Current	Ref.	Current	Ref.	Current	Ref.
①	●	—	●	—	●	—	●	—
Press once based on ①	—	●	—	●	—	●	—	•
Press twice based on ①	●	●	●	—	●	—	●	—
Press 3 times based on ①	●	●	—	●	—	●	—	●
Press 4 times based on ①	Same as ①		Same as ①		Same as ①		Same as ①	
Repeated same as above								

Chapter 4 Preparation Before Operation

■ 4.1 Flow before measurement

● The flowchart below shows procedures before measurement.

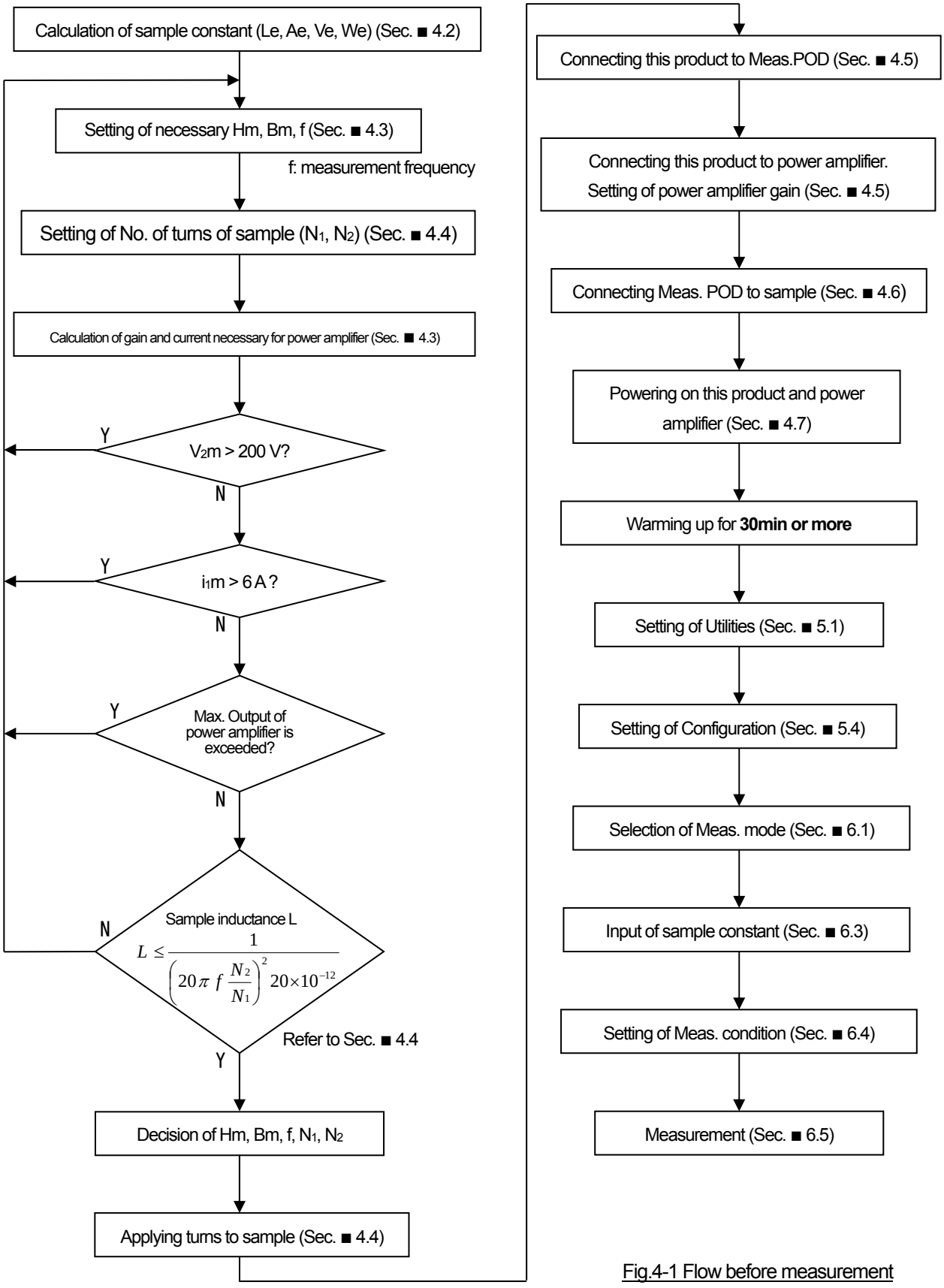


Fig.4-1 Flow before measurement

■ 4.2 Calculation of sample constants

- If a sample constant required for measurement is not attached to the sample, use the following calculation expression to obtain an approximate constant. For details, see JIS standard and the like.

■ Toroidal core

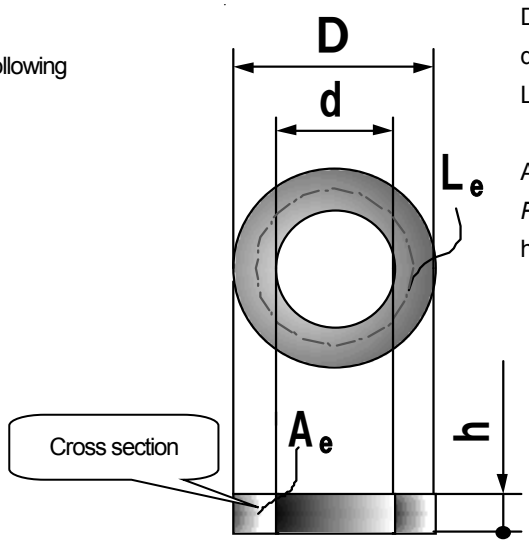
For a toroidal core with the shape shown in Fig.4-2, use the following calculation expression to obtain the sample constant:

Effective length of magnetic path: $L_e \cong \frac{\pi(d+D)}{2}$ (4.1)

Effective net core area: $A_e \cong \frac{(D-d)h}{2}$ (4.2)

Effective volume: $V_e \cong L_e \cdot A_e$ (4.3)

Mass: $W_e \cong \rho \cdot V_e$ (4.4)



D: Outer diameter
d: Inner diameter
Le: Effective length of magnetic path
Ae: Effective net core area
P Density
h Height

Fig.4-2 Toroidal core

■ EI core

For an EI core with the shape shown in Fig.4-3, use the calculation expression to obtain the sample constant:

Effective length of magnetic path: $L_e \cong a + 2b - c - \frac{d}{2} - e + f$ (4.5)

Effective net core area: $A_e \cong d \cdot h$ (4.6)

Effective volume: $V_e \cong L_e \cdot A_e$ (4.7)

Mass: $W_e \cong \rho \cdot V_e$ (4.8)

ρ: Density
h: Height

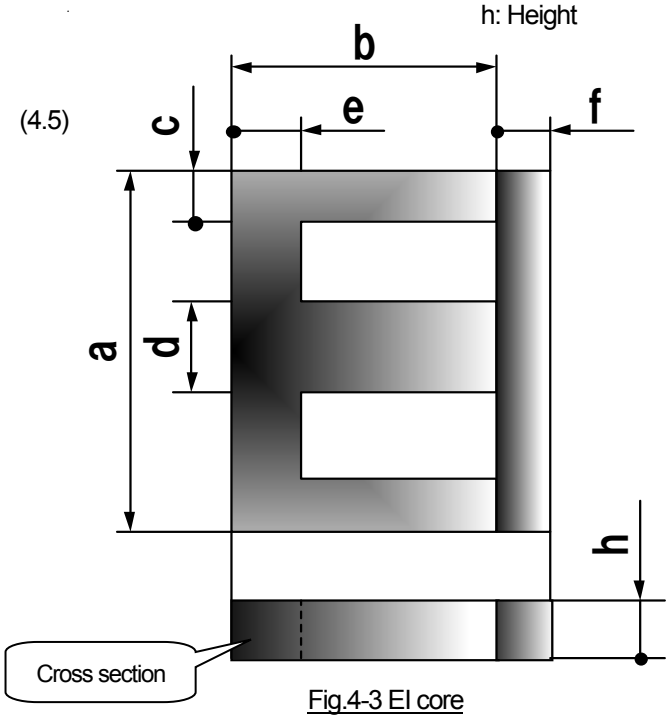


Fig.4-3 EI core

■ 4.3 Calculation of gain and current necessary for power amplifier

● When using a power amplifier, its gain and current should be predicted in advance. The procedure is described below.

* The explanation below is written assuming that a waveform to be observed is an ideal sine wave or an ideal symmetry square wave with Duty of 50%. Under a measurement condition which is not in this ideal state because of characteristics of a sample, the obtained gain below should be used as a standard.

■ Prediction of gain by using Max. magnetic flux density Bm

The following is the procedure to predict a gain necessary for a power amplifier using Max. magnetic flux density Bm generated in a sample.

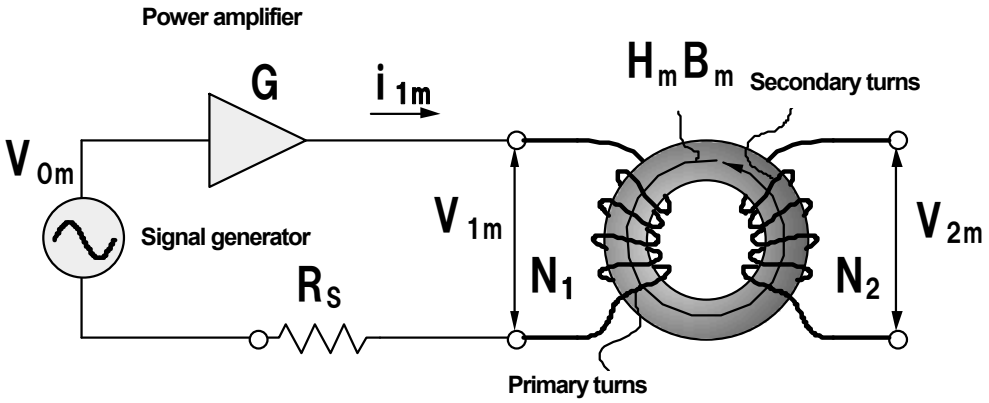


Fig.4-4 Measurement system

Le: Effective length of magnetic path
Ae: Effective net core area
N_1: No. of primary turns
N_2: No. of secondary turns
V_{2m}: Max. induced voltage
V_{1m}: Max. exciting voltage
V_{0m}: Max. signal output voltage
i_{1m}: Max. exciting current
Hm: Max. magnetic field
Bm: Max. magnetic flux density
G: Power amplifier gain
Rs: Shunt resistance value

① Define the measurement frequency f and the Max. magnetic flux density Bm to be generated in the sample, and then obtain Max. induced voltage V_{2m} using expression (4.9) if the excitation signal is a sine waveform or using expression (4.10) if it is a symmetry square waveform with Duty of 50%.

For excitation signal of sine wave: $$V_{2m} = 2\pi f N_2 B_m A_e \quad (4.9)$$

For excitation signal of symmetry square waveform with Duty of 50%: $$V_{2m} = 4 f N_2 B_m A_e \quad (4.10)$$

If V_{2m} exceeds 200[V], this product cannot make measurement; i.e. Maximum measurement induced voltage of this product is 200[V].

Never enter any voltage exceeding 200[V] in this product. Otherwise, it may fail. Moreover, do not use the power amplifier exceeding the rated power. Otherwise, it may fail.

② Next, obtain the maximum exciting voltage V_{1m} which is obtained by converting Max. induced voltage V_{2m} into the primary turns side, using expression (4.11). It can be applied independent of a type of the exciting signal.

$$V_{1m} = \frac{N_1}{N_2} \cdot V_{2m} \quad (4.11)$$

If V_{1m} exceeds the maximum output voltage of the power amplifier to be used, it is considered that any measurement cannot be made under this condition. Originally at this step, in consideration of the voltage descent of the shunt resistance, the current that flows to the primary side of the sample is not predictable. Moreover, the voltage descent of this shunt resistance is not considered because it is small.

③ Using results above, obtain the gain G required for the power amplifier using the maximum signal output voltage **V_{0m}=2.8[$V_{0\text{-}p}$]** of this product and expression (4.12).

$$G = \frac{V_{1m}}{V_{0m}} \cdot \quad (4.12)$$

④ Set the power amplifier to a value which exceeds the obtained gain G and is the lowest in the settable gains.

■ **Prediction of current by using Max. magnetic field Hm**

The following is the procedure to predict the current necessary for a power amplifier using Max. magnetic field Hm to be applied to a sample. It can be set independent of a type of an exciting signal.

① Define Max. magnetic field Hm to be applied to a sample and then obtain Max. exciting current i_1m (i_1m is the same as I_1m in Section ■ 4.4 Turns of a sample or later) using expression (4.13).

$$i_{1m} = \frac{L_e H_m}{N_1} \qquad (4.13)$$

If i_1m exceeds 6.0[A], this product cannot make measurement. In addition, if the maximum output current of a power amplifier used is exceeded, it is considered that measurement cannot be made under this condition.

⚠ **Never enter any current exceeding 6[A] in this product. Otherwise, it may fail.**
Moreover, do not use the power amplifier exceeding the rated current. Otherwise, it may fail.

■ 4.4 Turns of a sample

- The following is the example of applying turns to a sample.

■ No. of turns

No. of turns is the important factor deciding Max. magnetic field Hm and Max. magnetic flux density Bm. Basically, Iwatsu recommends that:

- No. of primary turns N_1 should be 3 turns or more, No. of secondary turns N_2 should be 1 turns or more, and N_1 is equal to N_2 as much as possible.

No. of turns should be determined considering above and referring to Section 4.3 while taking notice of below:

① Necessary Hm and Bm are obtained and V_2m does not exceed 200[V]. I_1m does not exceed 6[A]. In addition. if a power amplifier is used, V_1m and I_1m do not exceed the maximum output of the power amplifier.

② To avoid resonance caused by a sample and the input capacitance of this product when making measurement with a measurement frequency f [Hz], the inductance L [H] of the sample to which turns is applied should satisfy expression (4.14).

$$L \leq \frac{1}{\left(20\pi f \frac{N_2}{N_1}\right)^2 20\times10^{-12}} \qquad (4.14)$$

* L should be obtained by inductance measurement.

■ How to apply turns

If No. of primary turns N_1 is equal to No. of secondary turns N_2, the bifilar winding shown in Fig. 4-5 is recommended. It is made by making a twisted pair using primary and secondary lines and winding the pair onto the core.

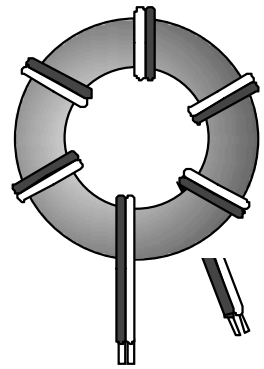


Fig.4-5 Bifilar winding

The magnetic flux for the bifilar winding leaks less than when primary and secondary lines are wound individually: i.e. coupling coefficient between primary and secondary turns can be improved.

When make winding, take notice of below. Influence by leaked magnetic flux and eddy current can be reduced.

- When applying winding, adhere line material to a sample as close as possible.
- Intervals between turns are as equal as possible.
- Twisted pair interval between primary and secondary lines is as close as possible.
- The thickness of material of a winding line is as thin as possible within the range permitted by a maximum current used.

■ Termination processing of windings

Knots should be made at both ends of primary and secondary lines as marks as shown in Fig. 4-6 so that wrong connection to the measurement POD is reduced.

Fig.4-6 Termination processing of winding

■ 4.5 Connection of equipments

● The following shows how to connect equipments necessary for measurement.

■ **Connecting the main unit and the measurement POD.**

The following is the procedure to connect the measurement POD to the main unit.

① Insert the measurement POD into the opening on the front of the main unit and press it into the bottom.

② Fix the measurement POD by clockwise rotating two clamp knobs on the measurement POD simultaneously. (See 1.3 Cautions for transportation" and Fig.1-1.)

⚠ When installing, removing, or replacing POD, make sure to **turn off POWER switch on the front panel of this product;** i.e. nothing appears on LCD screen.
Otherwise, this product **may fail**.

■ **Connecting the power amplifier**

The following is the procedure to use a combination of the power amplifier and this product.

① Connect OSC OUTPUT at the lower right on the front panel of the main unit with INPUT of the power amplifier using the provided OSC cable (BNC-SMA).

* Connect them with an optional OSC cable for SY-911 and IE-1125 when the power amplifier is IE-1125 or IE-1125x.

② Connect OUTPUT of the power amplifier with POWER INPUT at the left on the measurement POD using the provided power amplifier cable (BNC-BNC).

* If a power amplifier is not used, connect OSC OUTPUT at the lower right on the front of the main unit with POWER INPUT at the left of the measurement POD using the provided OSC cable (BNC-SMA).

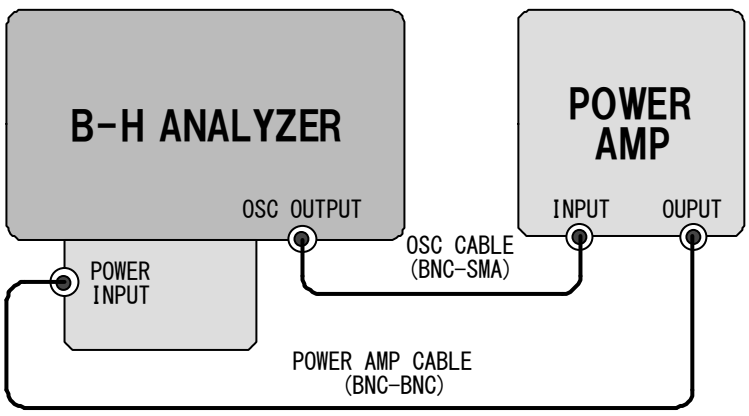


Fig.4-7 Connection of equipments

⚠ Before making connection, **make sure to read** the instruction manual of the power amplifier to be used. If reverse connection is made for input/ output of the power amplifier or this product, **fatal damage to this product or the power amplifier** may be caused.

■ 4.6 Connection of sample

● A sample is connected to the measurement POD as follows:

■ **2-coil method**

① Connect the start of the primary turns to P2 terminal and the end to P1 terminal.

② Connect the start of the secondary turns to S2 terminal and the end to S1 terminal.

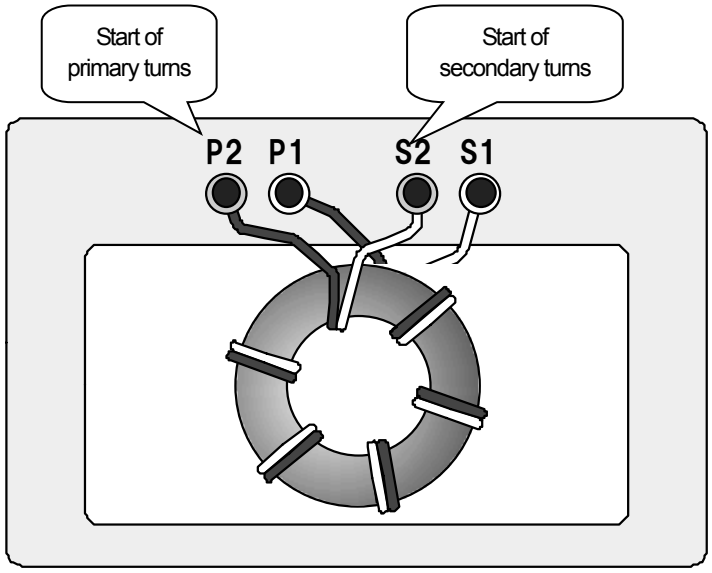


Fig.4-8 2-coil method

■ **1-coil method**

If the secondary turns cannot be applied, measurement uses 1-coil method. In this case, Core loss Pc includes the copper loss of the primary turns, therefore Pcv, Pcm, and θ include its influence. In addition, make sure to select 1-coil method in Configuration for measurement.
(For settings, see “5.4 Measuring Method”.)

① Connect the start of turns to P2 terminal and the end to P1 terminal.

② Short-circuit P2 and S2 terminals.

③ Short-circuit P1 and S1 terminals.

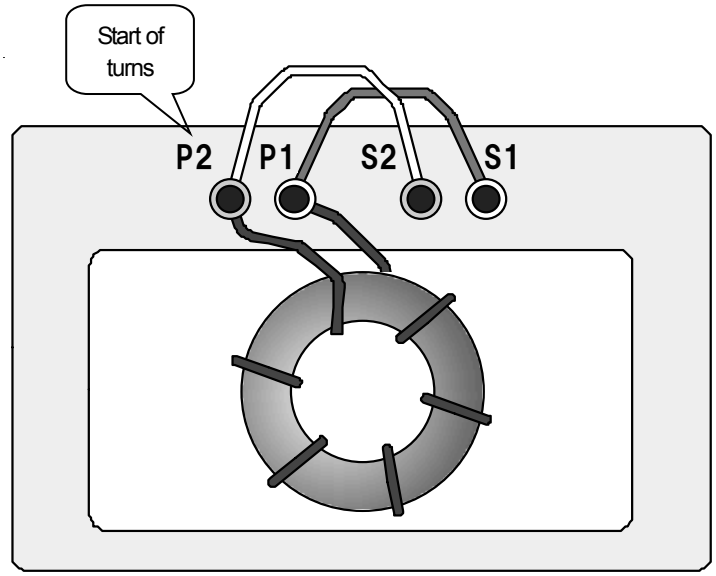


Fig.4-9 1-coil method

* It is recmmended that Fixed Parameter by 1-coil method is set in I1m and Hm specification.

Because the secondary turns is not given as for 1-coil method, induced voltage $V_2(t)$ in the basic measurement principle chart of Fig.2-2 will directly measure the voltage between the primary turns. In this case, it differs from 2-coil method, and voltage drop in shunt resistance R_S by exciting current $i_1(t)$ and equivalent series resistance R_L of sample will be superimposed to $V_2(t)$.

Therefore, the measurement might not go well because of the superimposition when I1m or Hm is specified for the target parameter. Especially, voltage drop in shunt resistance R_S and equivalent series resistance R_L grows when exciting current $i_1(t)$ grows, and, in addition, the measurement doesn't go well.

■ 4.7 Powering on and off

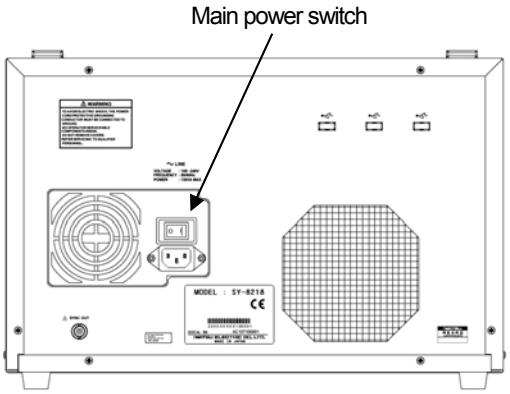


Fig.4-10 Main power switch on the rear

- The following is method to power on/ off this product

■ Powering on

① Turn on the main power switch on the rear of this product.
* Advance to following ② after you wait for a few seconds after the main power source is turned on.
Error E08 occurs if not neatly waiting.

② Turn on POWER switch by pressing it at the lower left of the front panel.
* Press POWER switch in the state where a USB memory is not inserted. If not, this product may not start.

③ After Windows desktop screen appears for a while on the LCD screen of this product, the start progress bar screen appears for **approx. 1 min**, the bar disappears and then this product is ready to operate.
* When the progress bar appears after turning on POWER switch, never press POWER switch at the lower left of the panel. Otherwise, this product may malfunction.

④ Before starting measurement, **warm up this product 30 minutes or more** after the progress bar disappears (in ③).
* For warming up of a power amplifier, refer to the instruction manual of it.

> Caution!
> **Explanatory note that a low frequency sound may be generated when turning on the switch on the rear. It does not affect characteristics and life of this product at all**, because it is caused by a low frequency vibration in transition of a choke coil for high-frequency measures.

■ Powering off

① Press POWER switch at the lower left on the front panel of this product. The screen changes to blue and after **approx.30 seconds**, this product is powered off.

② After nothing appears on LCD screen, turn off the main power switch on the rear.
* Turn off the power supply of the power amplifier after turning off the power supply of this product when you use the power amplifier.

■ Memorizing measurement conditions

① When powering on again, the measurement screen in the measurement mode just before previous powering off is displayed and measurement conditions at that time are used.

Chapter 5 Setting Before Measurement

■ 5.1 Setting of Unit

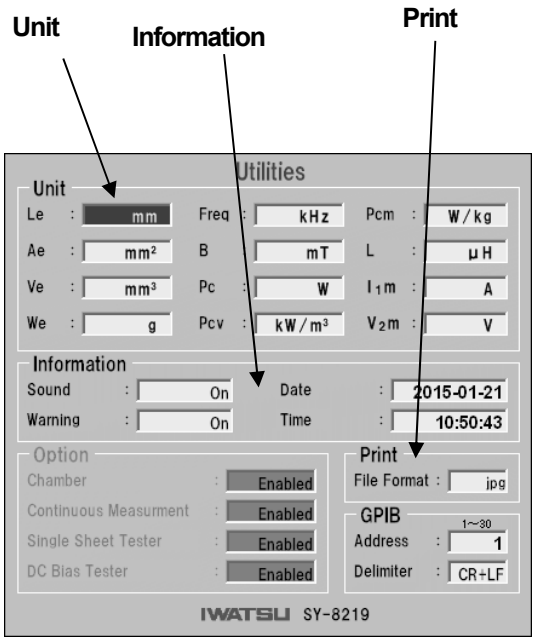


Fig.5-1 Utilities screen

- It sets the units of a measurement value and a sample constant.

① Press UTILITIES to display Utilities screen (see Fig.5-1).

② Move the edition cursor to the measurement value whose **unit** is to be changed or List Box of the sample constant and press ENTER.

③ Popup List opens. Move the edition cursor to the Selectable unit and press ENTER to determine it.

Table 5-1 explains each symbol and shows units to be selected.

④ Press UTILITIES or EXIT to close Utilities screen.

* If the other item is to be changed, Utilities screen need not be closed.

Table 5-1 Setting of units

[Explanatory note] **Bold**: Factory settings

Symbol (description)	Selectable unit	Symbol (description)	Selectable unit	Symbol (description)	Selectable unit
Le (Effective length of magnetic path)	**mm** cm m	**Freq.** (Measurement frequency)	Hz **kHz** MHz	**Pcm** (Core loss per mass)	**W/kg** W/g mW/g
Ae (Effective net core area)	µm² **mm²** cm² m²	**B** (Magnetic flux density)	**mT** T	**L** (Inductance)	**µH** mH H
Ve (Effective volume)	**mm³** cm³ m³	**Pc** (Core loss)	mW **W**	**I_1m** (Exciting current)	mA **A**
We (Net volume)	**g** kg	**Pcv** (Core loss per volume)	W/m³ **kW/m³** mW/cm³	**V_2m** (Induced voltage)	mV **V**

■ 5.2 Setting of Information

- It sets the information to be generated from this product.

① Press 

to display Utilities screen (see Fig.5-1).

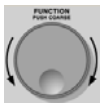
② Move the edition cursor to List Box of the output information whose **Information** is to be changed and press 

.

③ If Popup List opens, move the edition cursor to the item to be set and press 

to determine the setting.

④ If Popup Edit Box opens, use ten keys to enter a number and press 

. Or, move the edition cursor to the a number to be changed and press 
. Or, rotate 
to change a number and press 

to determine the setting.

Table 5-2 shows description of each output information and selectable items.

⑤ Press 

or 

to close Utilities screen.

Table 5-2 Setting of output information

[Explanatory note] **Bold**: Factory settings

Items	Selectable items	Description	
Sound	**On**	Sound on	Selection of whether or not start sound of this product, measurement finish sound, operation sounds for operation panel and keys is generated.
	Off	Sound off	
Warning	**On**	Message appears	Selection of whether or not an error message and warning message is displayed on the screen.
	Off	No message	
Date	—	Sets date of this product.	
Time	—	Set time of this product.	

■ 5.3 Setting of Print

● It sets the file format and output destination of a screen hardcopy

① Press 

to display Utilities screen (see Fig.5-1).

② Move the edition cursor to List Box of **Print** item to be changed and press 

.

③ When Popup List opens, move the edition cursor to item to be set and press 

to determine the setting.

Table 5-3 shows description of each item and selectable items.

④ Press 

or 

to close Utilities screen.

Table 5-3 Setting of screen hardcopy

[Explanatory note] **Bold**: Factory settings

Items	Selectable items	Description	
File Format	**jpg**	jpg format	* 5-1 Sets file format of a screen hardcopy.
	png	png format	

* **5-1**: The destination of the output of the screen hard copy is USB memory. When optional remote software SY-810 is used, the output destination becomes connected PC.

■ 5.4 Setting Measuring Method

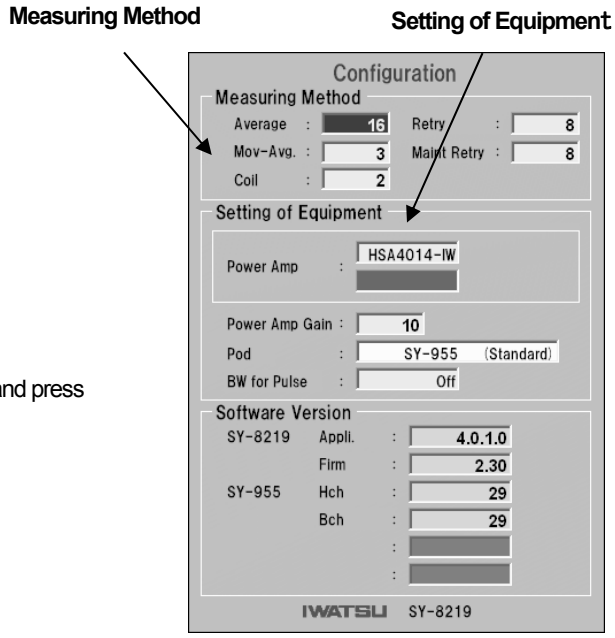


Fig.5-2 Configuration screen

- It sets the measurement method.

① Press CONFIG to display Configuration screen (seeFig.5-2).

② Move the edition cursor to List Box of a measurement item for which **Measuring Method** is to be changed and press ENTER.

③ When Popup List opens, move the edition cursor to the item to be set and press ENTER to determine the selection.

Table 5-4 shows description of each item and selectable items.

④ Press CONFIG or EXIT to close Configuration screen.

* If another item needs to be changed, Configuration screen need not be closed.

Table 5-4 Setting of measurement method

[Explanatory note] **Bold**: Factory settings

Items	Selectable items	Description	
Average	Power of 2^0 - 2^6	Selects No. of averaging times of measurement signal waveform *5-2 (1, 2, 4, 8, 16, 32, 64)	
	16		
Retry	Power of 2^3 - 2^5	Selects the upper limited No. of times of excitation until values of specified Fixed Parameter (target parameter) converge within Tolerance *5-3 Maint Retry mode is used only for service and not disclosed to a customer.	
	8		
Maint Retry	Power of 2^3 - 2^5		
	Free		
	8		
Mov-Avg	Odd in 1 - 111	Selects the moving average number applied to sample data of a measurement signal waveform *5-4.	
	3		
Coil	1	1-coil method	Selects 1-coil method or 2-coil method to measure a sample.
	2	2-coil method	

* **5-2**: Increased number of times for averaging allows higher quality measurement. However, if the number of times for averaging is set too large, the measurement time may become long or temperature of a measured sample may rise depending on measured samples or measurement conditions, resulting in effect on a measurement value. Care should be taken.

* **5-3**: Normally, 8 are recommended for a default number of times. If the number is too large, the number of times for excitation increases which causes temperature of a sample to rise, **resulting in damage to the sample**.

* **5-4**: Increased number of times for moving average allows noise ingredients included in measurement signals to be reduced. However, if the number is too large, the original measurement signal may deteriorate.

■ 5.5 Setting of Equipment

- It sets the name of a power amplifier to be connected, the gain of the power amplifier, and the rise time of a pulse for pulse excitation.

① Press 

to display Configuration screen (see Fig.5-2).

② Move the edition cursor to List Box of a measurement item for **Setting of Equipment** to be changed and press 

.

③ When Popup List opens, move the edition cursor to the item to be set and press 

to determine the selection.

Table 5-5 shows description of each item and selectable items.

④ Press 

or 

to close Configuration screen.

Table 5-5 Setting of Equipment

[Explanatory note] **Bold**: Factory settings

Items	Selectable items	Description	
Power Amp	IE-1125 IE-1125A IE-1125B HSA4014-IW HSA4052-IW **HSA4101-IW** Other Not Used	• Select a power amplifier name to connect. The power amplifier name is displayed on the measurement screen and saved when data is **saved**. • If **Other** is selected, **Edit Box** just under it can accept an entry; i.e. an arbitrary amplifier name can be entered (up to **10** characters)>	
Power Amp Gain	Integral number 1 - 100 **10**	Selects a gain of a power amplifier to connect. A gain is displayed on the measurement screen and saved when data is **saved**.	
Pod	-	Displays the Pod name corresponding to the selected measurement mode.	
BW for Pulse	**Off** 100ns 200ns	BW filter—Off Approx. 100ns Approx. 200ns	Selects an approximate rise time of a pulse signal generated for pulse excitation. Setting to Off makes the rise time fastest.

Table 5-6 Options and measurement PODs corresponding to them

Chapter 6 Measurement

■ 6.1 Selecting measurement mode

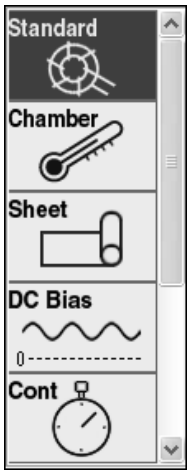


Fig.6-1 Mode menu

- It selects a measurement mode.

① Press MODE to display Mode menu (see Fig.6-1).

② While referring to Table 6-1, move the edition cursor to the mode to be used for measurement*6-1 and press ENTER to determine the selection.

③ The screen of the selected measurement mode appears.

④ Press MODE or EXIT to close Mode menu screen.

* **6-1**: This product recognizes connected measurement POD automatically. If measurement POD connected with the selected measurement mode is not corresponding, error E12 is displayed when the measurement begins. After the stop of the power supply, try to connect the correct POD again.

Table 6-1 Measurement modes and displayed measurement POD names

Measurement modes	Measurement POD names	Descriptions
Standard	SY-951	Standard measurement POD for SY-8218
Cont	SY-955	Standard measurement POD for SY-8219
Chamber	SY-320x / 321x	Chamber Scanner System
Sheet	SY-956	Mini Single Sheet Tester
DC Bias	SY-960	DC Bias Tester

■ 6.2 Measurement screen

- The measurement screen is outlined.

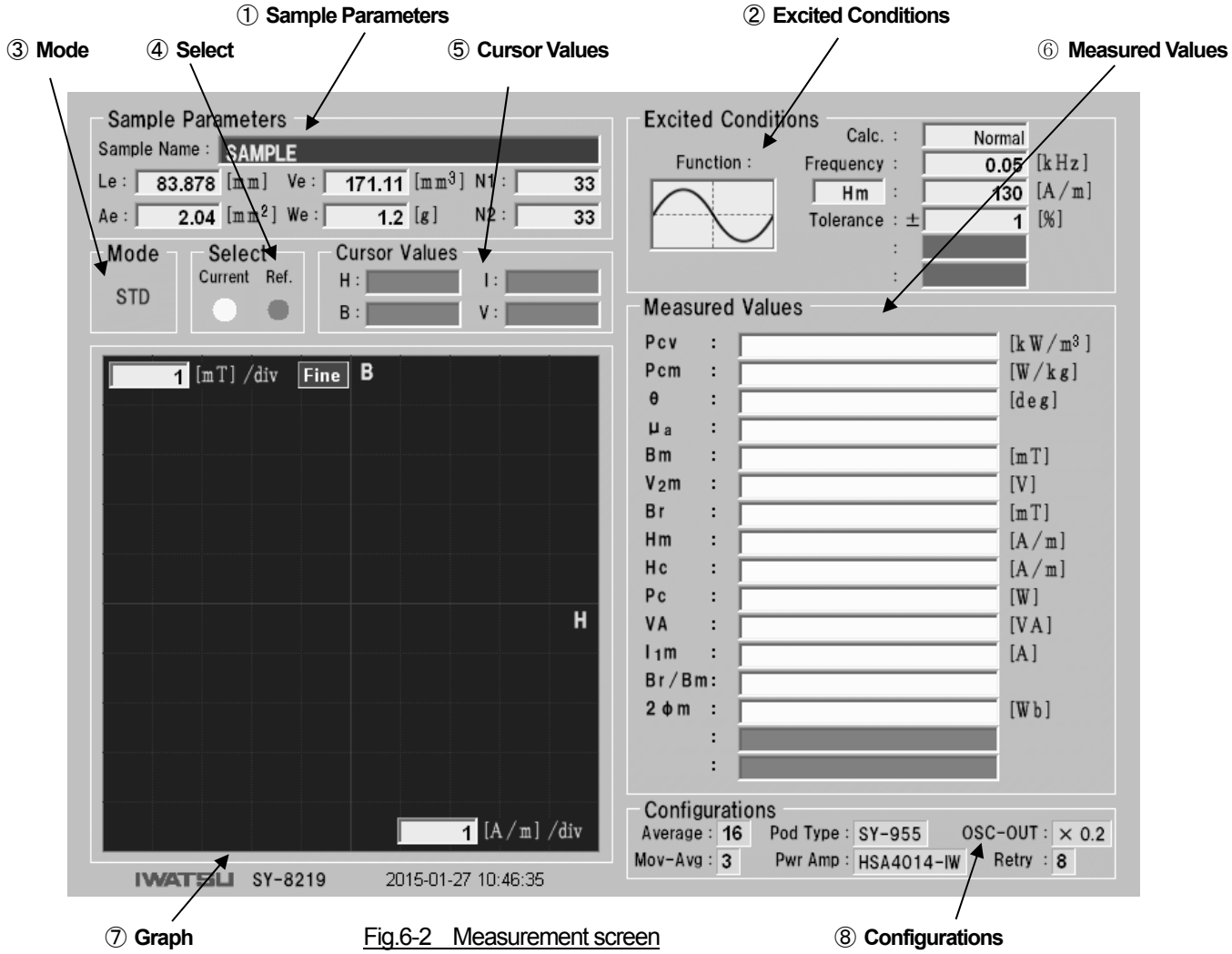


Fig.6-2 Measurement screen

① **Sample Parameters** : Sets the sample name and the sample constant.

② **Excited Conditions** : Sets the measurement condition.

③ **Mode** : Displays the current measurement mode.

④ **Select** : Indicates whether the currently displayed graph is Current (for current measurement) or Reference (for saved measurement).

⑤ **Cursor Values** : Displays the cursor value when the cursor appears.

⑥ **Measured Value** : Displays the measurement value.

⑦ **Graph**: Displays B-H graph or time axis graph.

⑧ **Configurations**: Displays main values being set in Configurations.

■ 6.3 Input of sample constant

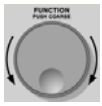
- The sample constant of a measured sample is entered.

① While referring to Table 6-2, move the edition cursor to Edit Box of the sample constant to be entered on **Sample Parameters** and press 

to determine the selection.

② When Popup Edit Box opens, while referring to "Input rules" in Table 6-2, use the ten key to enter alphanumeric characters and press 

or move the edition cursor to the alphanumeric character to be changed press  .

Or, rotate  to change the number . Press 

to determine the entry and to close Popup Edit Box.

Table 6-2 Sample constant

[Explanatory note] **Bold**: Factory settings

Items	Input rules	Description
Sample Name	Up to 20 characters **None**	Sample name
Le	0.001 - 99999 **10**	Effective length of magnetic path
Ae	0.001 - 99999 **10**	Effective net core area
Ve	0.001 - 99999 **100**	Effective volume
We	0.001 - 99999 **1**	Mass
N1	0.1 - 9999.9 **1**	Primary turns
N2	0.1 - 9999.9 **1**	Secondary turns

■ 6.4 Setting of measurement condition

● The measurement condition is set.

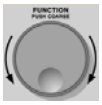
① While referring to Table 6-3, move the edition cursor to Edit Box of the measurement condition to be entered on **Excited Conditions** and press 

to determine the selection.

② When Popup List opens, move the edition cursor to the item to be set and press 

to determine the setting.

③ When Popup Edit Box opens, use the ten key to enter the number and press 

. Or move the edition cursor to the number to be changed and press 
. Or, rotate 
to change the number. Press 

to determine the setting.

Table 6-3 Measurement condition

[Explanatory note] **Bold**: Factory settings

<table>
<tr><th colspan="2">Items</th><th colspan="3">Selectable items/ input rules</th><th colspan="2">Description</th></tr>
<tr><td colspan="2" rowspan="2">Function</td><td colspan="3">Sine</td><td>Sine wave</td><td rowspan="2">Selects a type of excitation signal.</td></tr>
<tr><td colspan="3">Pulse</td><td>*6-2 Square wave</td></tr>
<tr><td colspan="2" rowspan="2">Calc.</td><td colspan="3">Normal</td><td colspan="2" rowspan="2">Selects calculation mode.</td></tr>
<tr><td colspan="3">μ</td></tr>
<tr><td rowspan="3">Frequency</td><td rowspan="2">Sine wave</td><td>SY-8218</td><td colspan="2">10Hz to 10MHz</td><td colspan="2" rowspan="3">Selects a frequency of excitation signal.</td></tr>
<tr><td>SY-8219</td><td colspan="2">10Hz to 1MHz</td></tr>
<tr><td colspan="3">100</td></tr>
<tr><td>Square wave</td><td colspan="3">10Hz to 1MHz</td><td colspan="2">Selects a frequency of excitation signal.</td></tr>
<tr><td colspan="2" rowspan="5">Fixed Parameter
(Target parameter)</td><td colspan="2">Bm (Max. magnetic flux density)</td><td rowspan="4">0.001 to 99999</td><td colspan="2" rowspan="5">*6-3 Selects and sets a target parameter value for measurement.</td></tr>
<tr><td colspan="2">Hm (Max. magnetic field)</td></tr>
<tr><td colspan="2">I1m (Max. excitation current)</td></tr>
<tr><td colspan="2">V2m (Max. induced voltage)</td></tr>
<tr><td colspan="3">1</td></tr>
<tr><td colspan="2" rowspan="2">Tolerance</td><td colspan="3">0.1~100%</td><td colspan="2" rowspan="2">*6-3 Sets the tolerance X. The tolerance X is used for the criteria to finish measurement; i.e. X [%] is the ratio of an actual value to a target parameter setting value and if X is reached, measurement finishes.</td></tr>
<tr><td colspan="3">1</td></tr>
</table>

* **6-2**: μ mode cannot select a square wave. This product generates the symmetry square wave with **Duty=50 %**.

* **6-3**: To understand the meaning of the target parameter and Tolerance, it is necessary to understand the measurement process of this product.
The measurement process of this product is explained referring to Fig.6-3 which indicates the measurement process specifying Max. magnetic field Hm as a target parameter, setting Tolerance=x [%], and using the horizontal axis as time.

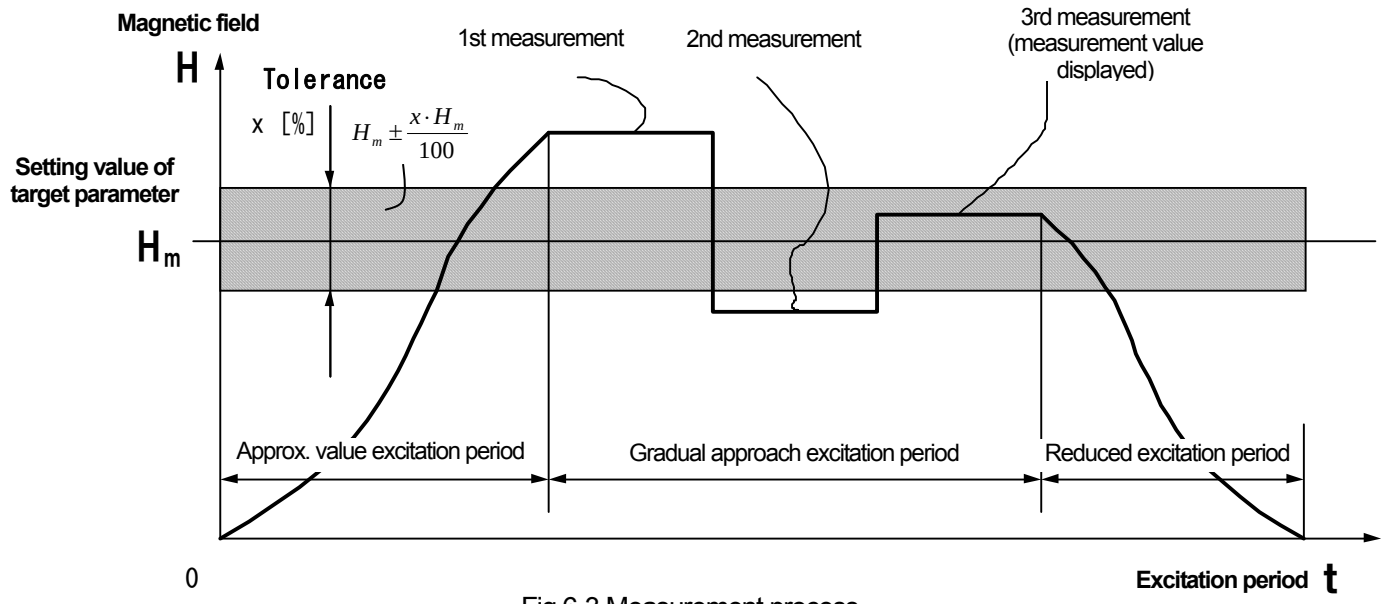


Fig.6-3 Measurement process

When measurement starts, this product gradually increases the signal output and excites a sample while observing a peak value of the magnetic field H.
And then, when H exceeds a specified setting value Hm, this product makes the 1st measurement while keeping the excitation status. The period after starting the excitation until H exceeds Hm is called an **approx. value excitation period**.

If H obtained in the 1st measurement is within the range of $H_m \pm \frac{x \cdot H_m}{100}$, the measurement finishes at that time, magnetization is reduced from the sample so that any residual magnetization is not left, and the measured value is displayed. If H is not within the range, the signal output is changed so that H can approach to Hm while exciting the sample.
In this period, the 2nd measurement is made and the same processing as the 1st measurement is done. This period is called **Gradual approach excitation period**.

That is, until the specified value of the target parameter become within the setting Tolerance, this product repeats measurement while changing the signal output.
The upper limit number of retries is set by **Retry** on **Configuration** screen.

If a measurement result is not within a setting Tolerance after measurement is repeated by the number of Retry times, the warning message "**W60**: Retry over!" is displayed and the last measurement result after reduced magnetization is displayed.

⚠ As Tolerance becomes small, the measurement time increases, resulting in rising in a sample temperature. Therefore, care should be taken.

■ 6.5 Measurement

● Measurement is made.

① Press START to start measurement and to allow the message "Measuring !"to blink on the screen.

② When the measurement finishes normally, the message "Measuring !"disappears and the measurement result is displayed (see Fig.6-4).

③ To forcibly stop measurement after starting the measurement, press STOP. If no measurement is made at that time, the measurement result may show *.

* Since the time of one cycle becomes long as the measurement frequency becomes low, the time after pressing STOP until the measurement stops actually becomes long.

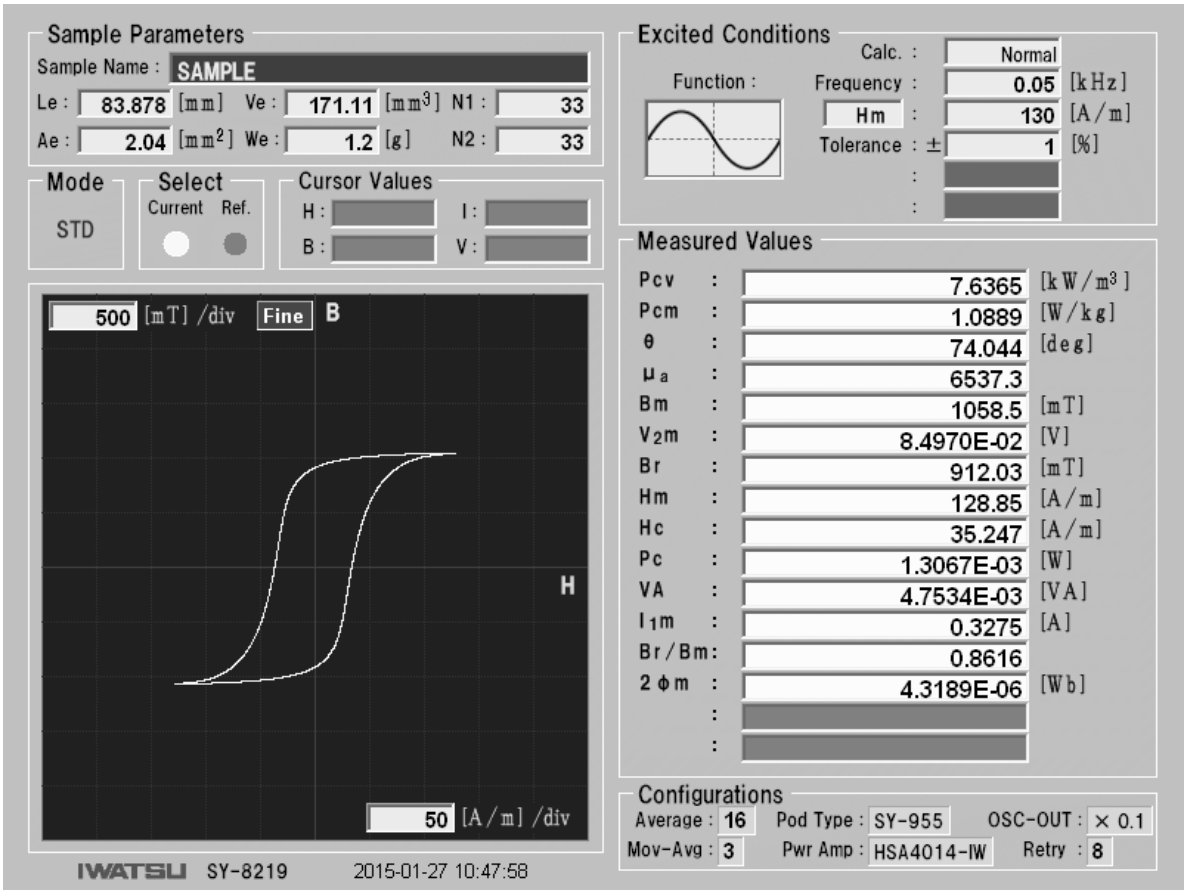


Fig.6-4 Measurement result

■ 6.6 Switching graph

- The displayed graph is switched.

① If 

is pressed when the measurement result shown in Fig.6-4 is displayed, the displayed graph changes from B-H graph to the time axis graph with its horizontal axis used as time shown in Fig.6-5

② If 

is pressed again, the displayed graph returns to B-H graph.

③ Two time axis graphs are displayed. Waveforms displayed in each graph are shown in Table 6-3.

Table 6-3 Measurement waveform for time axis graph

Graph	Line type	Symbol	Description	*6-4Unit
Upper side	Thick	B	Magnetic flux density	[mT]/div
	Thin	H	Magnetic field strength	[A/m]/div
Lower side	Thick	V	Induced voltage	[V]/div
	Thin	I	Exciting current	[A]/div

* **6-4:** Units for time axis graph are fixed: i.e. not changed.

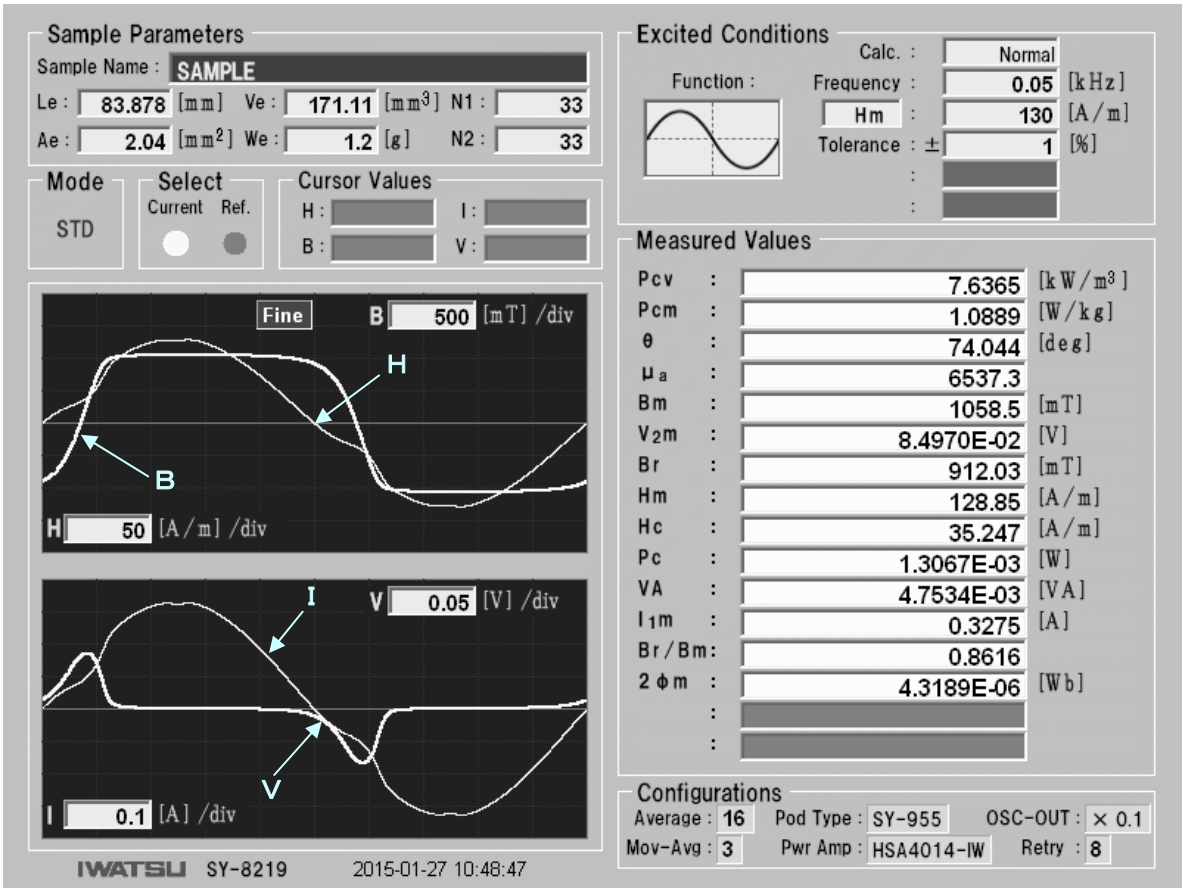


Fig.6-5 Time axis graph

■ 6.7 Cursor measurement

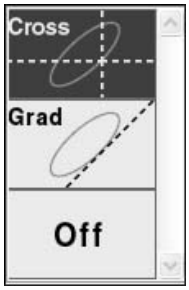


Fig.6-6 Cursor menu

■ 6.7.1 Cursor setting

① Press CURSOR to display the cursor menu shown in Fig.6-6.

② Move the edition cursor to an item to be set and press ENTER to determine the setting. The cursor being set is displayed.

* If ENTER is not pressed for **approx. 3 seconds**, the item on the edition cursor is set automatically.

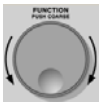
③ Items to be measured by each cursor are shown in Table 6-4.

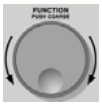
Table 6-4 Cursor types and measurement items

Cursor	Display graph	Measurement items
Cross	B-H	B (magnetic flux density), H (magnetic field strength)
	*6-5Time axis	B, H, V (induced voltage), I (exciting current)
Grad (grade)	B-H	μ (permeability)
	*6-5Time axis	B, H, V, I
Off		Cursor not displayed

* **6-5**: Even if Cross or Grad cursor is set for the time axis graph, the cursor is changed to the **vertical cursor** and the same items can be measured.

■ 6.7.2 Cross cursor measurement (on B-H graph)

① If  is rotated when Cross cursor is displayed, Cross cursor moves and the value of the point on the cursor is displayed on Cursor Values.

② Pushing  allows the movement amount of the cursor to toggle between Coarse (movement in unit of 20 points) and Fine (movement in unit of 1 point). For Fine movement, "**Fine**" is displayed at the upper side on B-H graph.

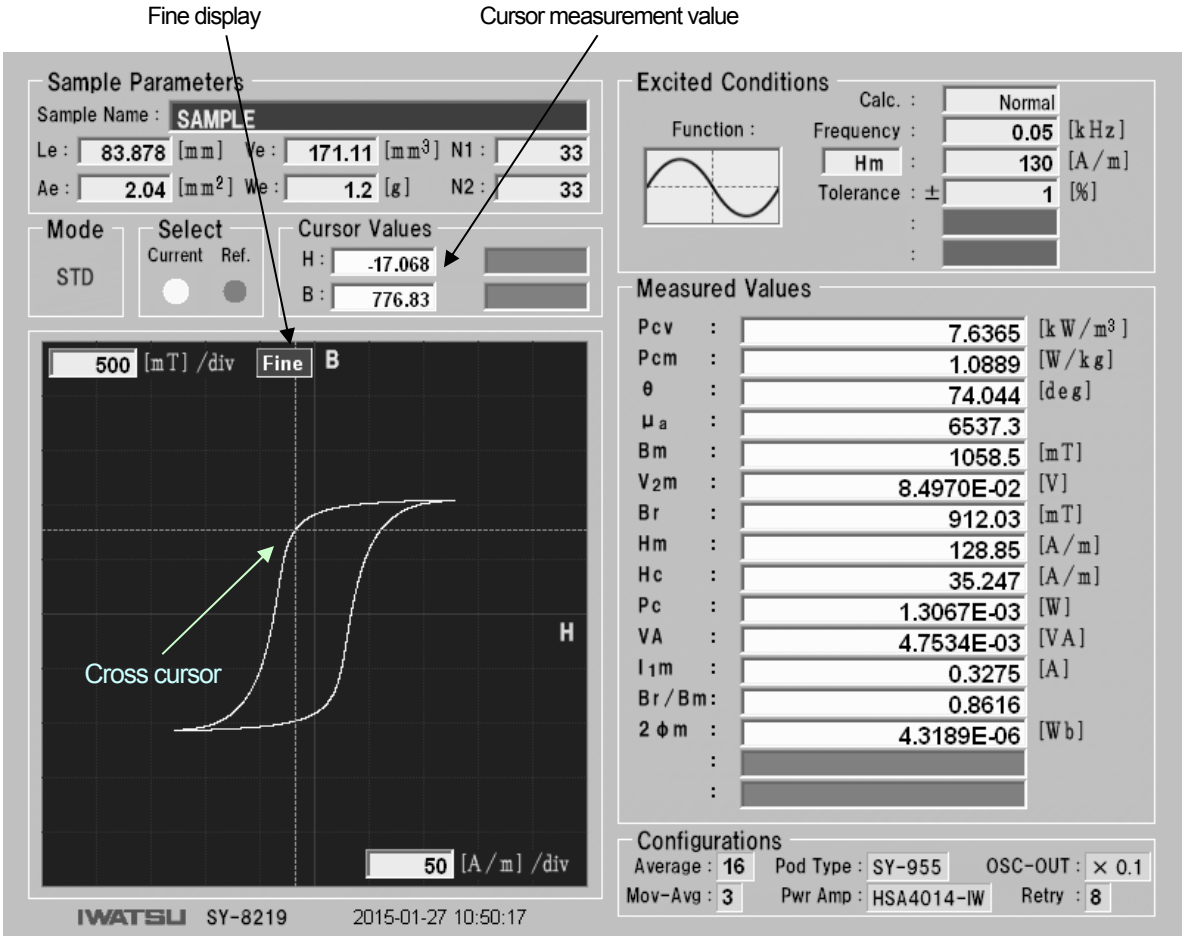
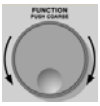
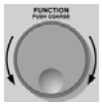


Fig.6-7 Cross cursor measurement on B-H graph

■ 6.7.3 Grad cursor measurement (on B-H graph)

① If  is rotated when Grad cursor is displayed, Grad cursor rotates and the incline value of the cursor (i.e. ratio permeability: $B/(\mu_0 \cdot H)$) is displayed. (B, H: Magnetic flux density and magnetic field strength at the center of cursor rotation, μ_0: vacuum permeability)

② The rotation center of Grad cursor is the **center of Cross cursor.** Therefore, if the position of the rotation center of Grad cursor is to be changed, change the cursor to Cross cursor and move the cursor position.

③ Pushing  allows the movement amount of the cursor to toggle between Coarse (movement in unit of 20 points) and Fine (movement in unit of 1 point). For Fine movement, "**Fine**" is displayed at the upper side on B-H graph.

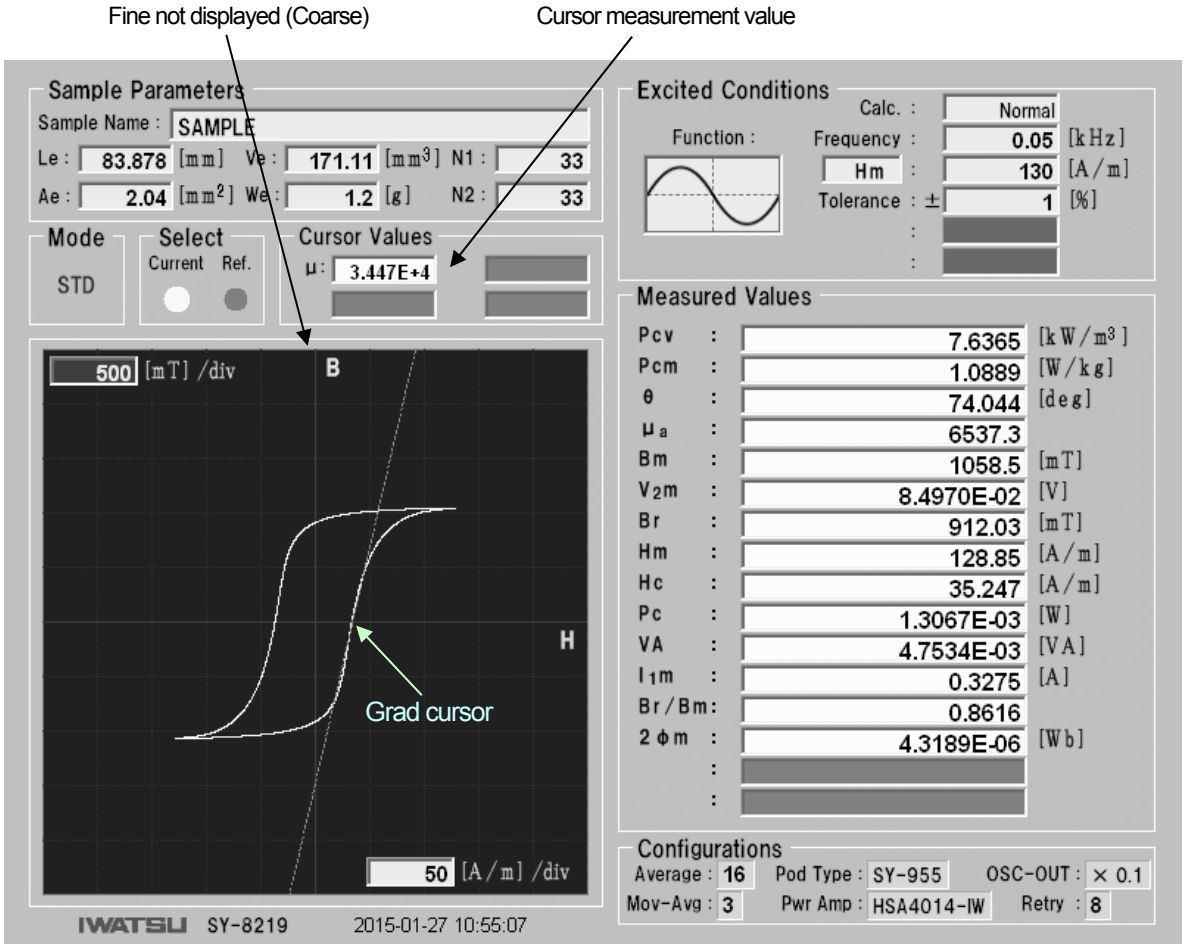
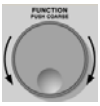


Fig.6-8 Grad cursor measurement on B-H graph

■ 6.7.4 Vertical cursor measurement (on time axis graph)

① If the graph display is changed to the time axis graph when Grad or Cross cursor is displayed, the cursor changes to the vertical cursor.

② If  is rotated when the vertical cursor is displayed, the vertical cursor moves and the value of the point on the cursor is displayed on Cursor Values.

③ Pushing  allows the movement amount of the cursor to toggle between Coarse (movement in unit of 20 points) and Fine (movement in unit of 1 point). For Fine movement, "**Fine**" is displayed at the upper side on B-H graph.

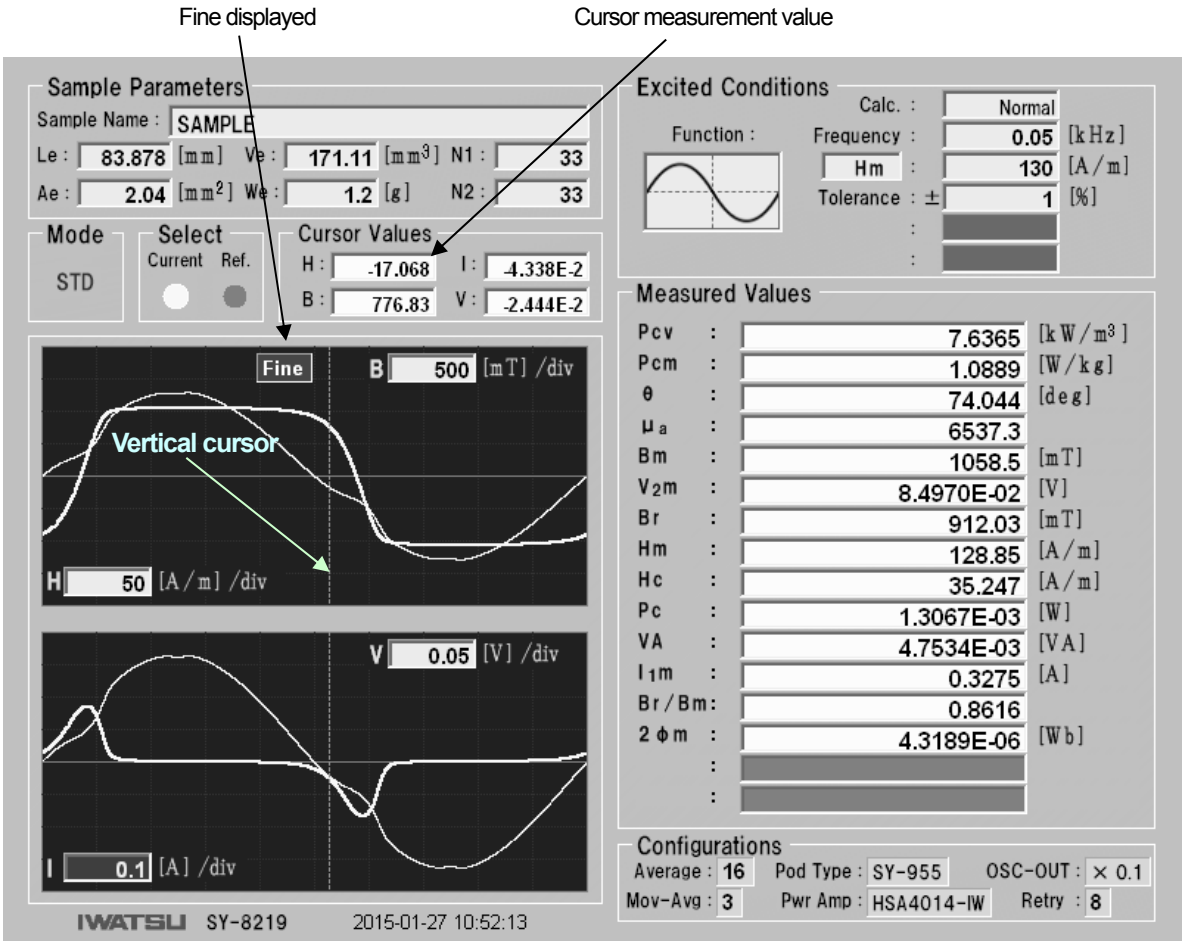


Fig.6-9 Vertical cursor measurement on time axis graph

■ 6.8 Scaling up/down of graph

● B-H graph is scaled.

① Move the Cross cursor to the position to be scaled when displaying Cross cursor*6-6.(see Fig.6-10).

② When B scale is to be scaled, move the edition cursor to the B scale List Box; when H scale is to be scaled, to the H scale List Box. And then press ENTER .

③ When Popup List opens, move the edition cursor to the scale to be set and press ENTER to determine the scale.

If a value larger than a current setting is selected, the displayed graph is scaled down, and if a smaller value is selected, the displayed graph is scaled up (see Fig.6-11).

④ Scales to be set are shown in Table 6-5. Selection of **Reset** allows the **displayed graph to return the original scale**.

* **6-6**: If Cross cursor is not displayed, the graph is scaled up/ down using the origin of the graph as a center.

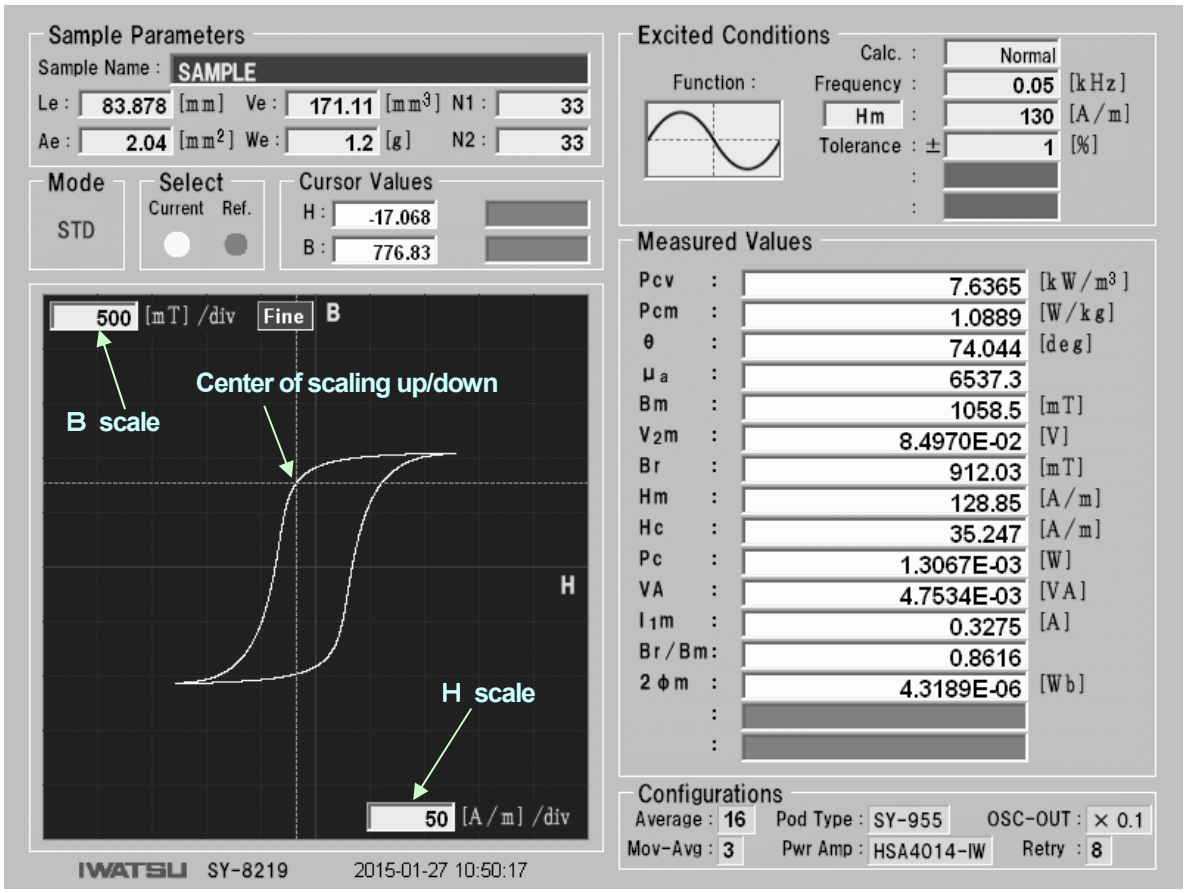


Fig.6-10 Setting of scaling up/ down by Cross cursor

Table 6-5 Selectable scales

Items	Unit	Selectable scales
H scale	[A/m]/div	Reset, 0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000, 5000, 10000
B scale	[mT]/div	Reset, 0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000

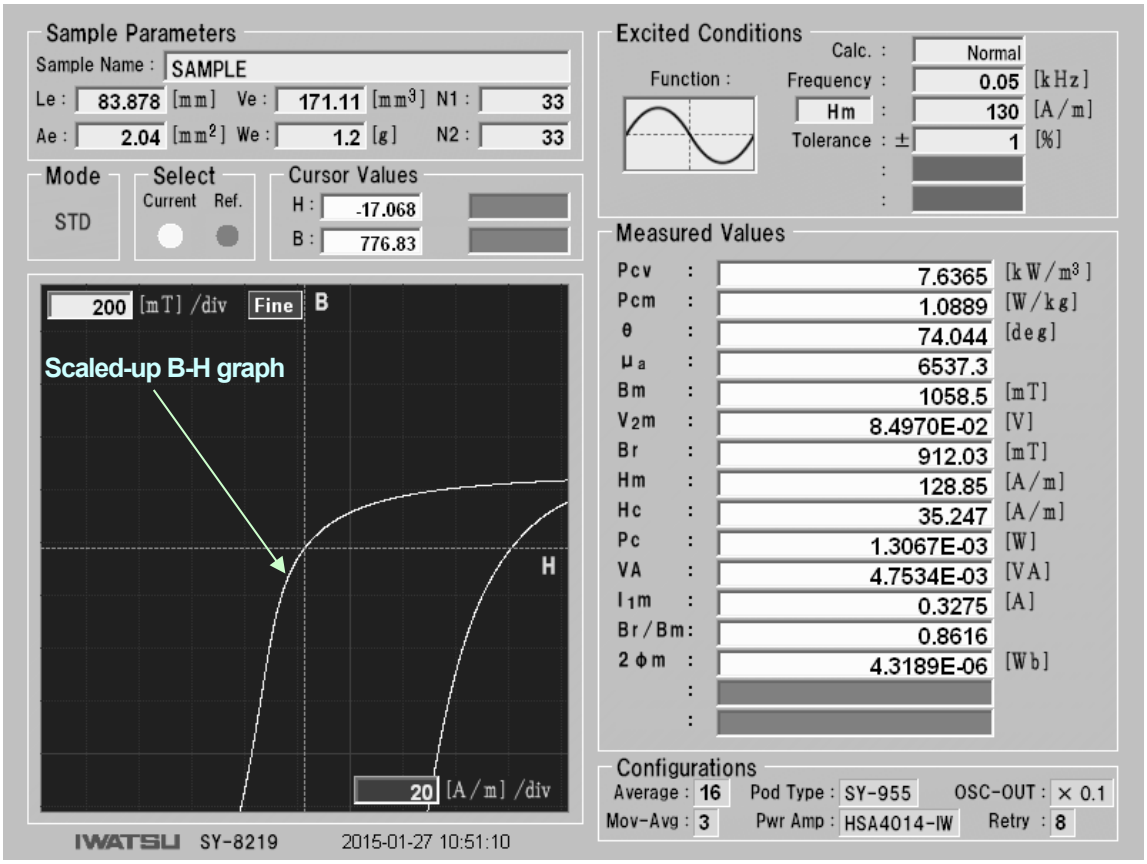


Fig.6-11 Scaling up of Fig.6-10

- The time axis graph is scaled up/ down.

① Press VIEW MODE to display the time axis graph (see Fig.6-12).

② When B scale is to be scaled, move the edition cursor to the B scale List Box; when H scale is to be scaled, to the H scale List Box; when V scale is to be scaled, to the V scale List Box; or when I scale is to be scaled, to the I scale List Box.

And then press ENTER. The time axis cannot be scaled up/ down.

③ When Popup List opens, move the edition cursor to the scale to be set and press ENTER to determine the scale.

If a value larger than a current setting is selected, the displayed graph is scaled down, and if a smaller value is selected, the displayed graph is scaled up (see Fig.6-13).

④ Scales to be set are shown in Table 6-6. Selection of **RESET** allows the **displayed graph to return the original scale**.

Table 6-6 Selectable scales

Items	Unit	Selectable scales
H scale	[A/m]/div	Reset, 0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000, 5000, 10000
B scale	[mT]/div	Reset, 0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000
I scale	[A]/div	Reset, 1E-6, 2E-6, 5E-6, 10E-6, 20E-6, 50E-6, 100E-6, 200E-6, 500E-6, 0.001, 0.002, 0.005, 0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 1, 2, 5
V scale	[V]/div	Reset, 1E-6, 2E-6, 5E-6, 10E-6, 20E-6, 50E-6, 100E-6, 200E-6, 500E-6, 0.001, 0.002, 0.005, 0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100

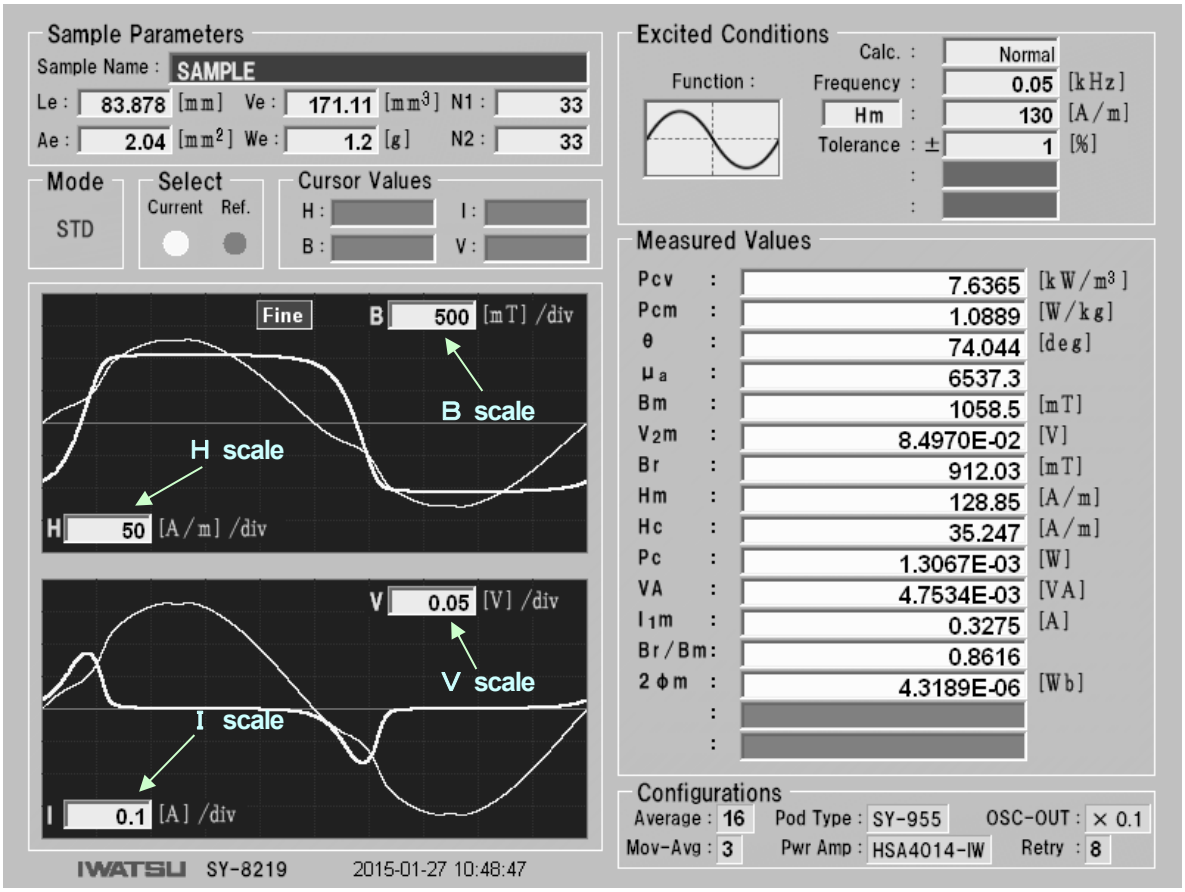


Fig.6-12 Time axis graph

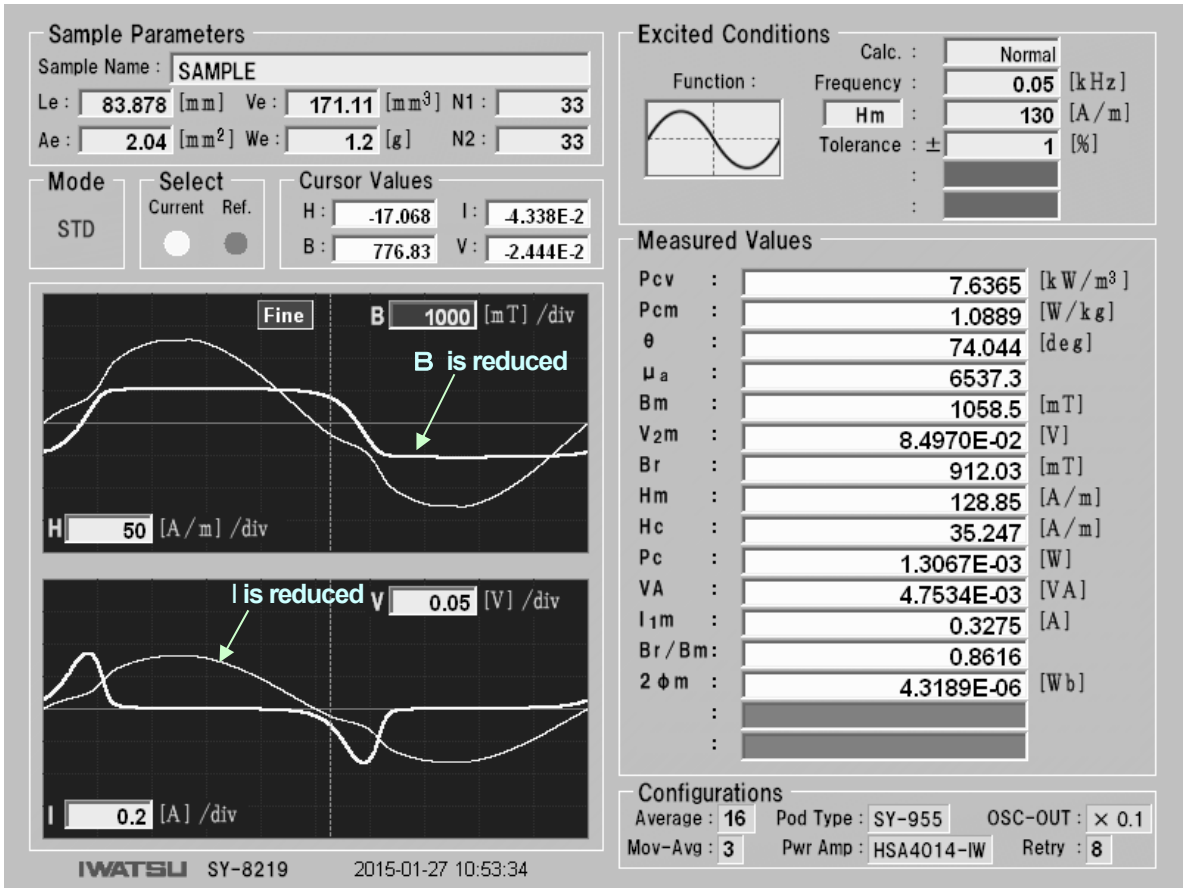


Fig.6-13 B and I in Fig.6-12 is scaled down

■ 6.9 Reference function

- Measurement using the reference function is explained. This product can **store one set** of measurement conditions or measurement values; i.e. a waveform which has been measured under the other measurement condition can be displayed at the same time, allowing waveform comparison. It is called **Reference function**. Hereinafter, a stored measurement result is called **Reference** (Ref.) and the latest measurement result not stored is called **Current**.

① When a measurement result is displayed, press STORAGE to make it **Reference**.

② Next, change the measurement condition and make another measurement. The measurement result is **Current**.

③ To display Reference, press SELECT. Each time it is pressed, the measurement condition and value change as shown in Table 6-7. Reference waveform is displayed in **light blue** and Current waveform in **yellow**. The status is indicated in **Select** on the measurement screen (see Fig.6-14 and Fig.6-15).

Table 6-7 Function of SELECT key

[Explanatory note] ● : display —: not display

Operation	Display graph		Cursor measure		Meas. condition		Meas. value	
	Current	Ref.	Current	Ref.	Current	Ref.	Current	Ref.
①	●	—	●	—	●	—	●	—
Press once based on ①	—	●	—	●	—	●	—	●
Press twice based on ①	●	●	●	—	•	—	●	—
Press 3 times based on ①	●	●	—	●	—	●	—	●
Press 4 times based on ①	Same as ①		Same as ①		Same as ①		Same as ①	
Repeated same as above								

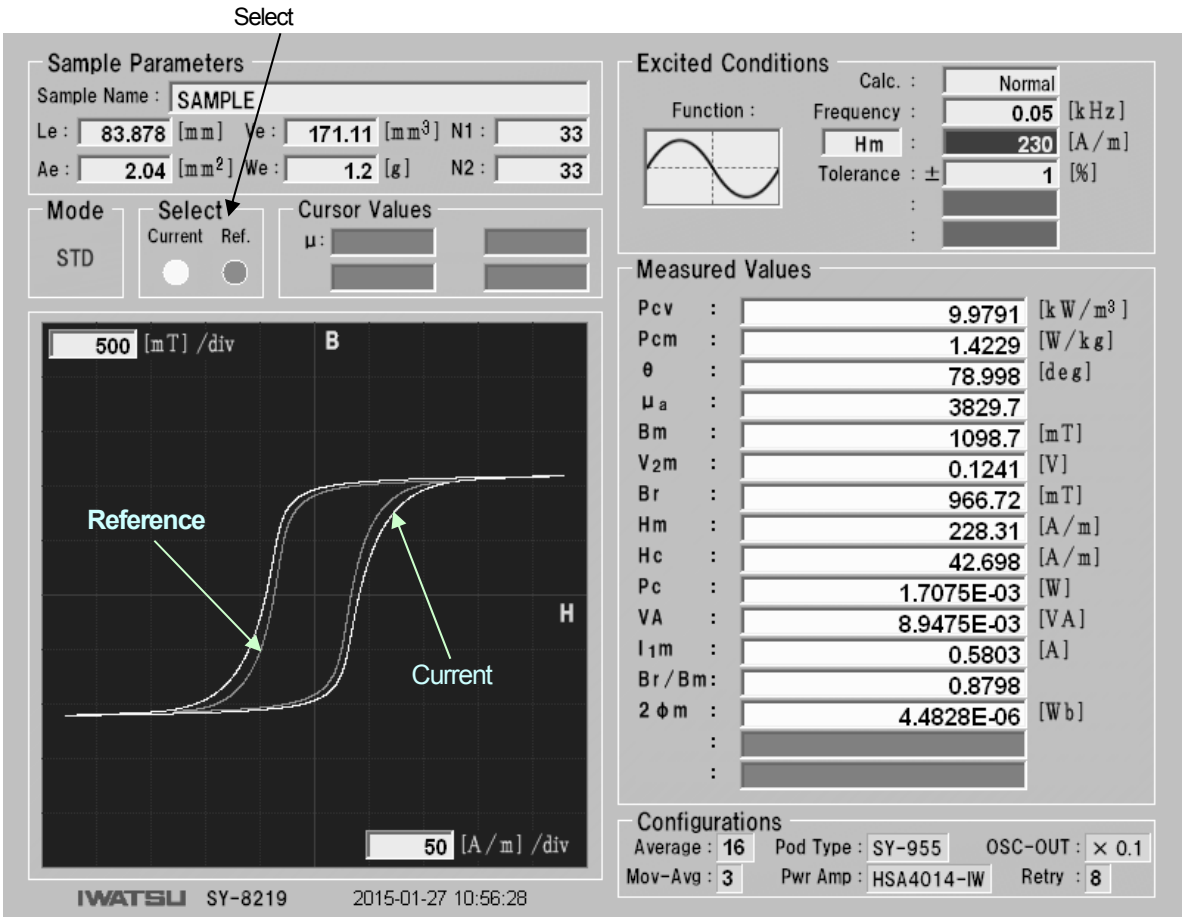


Fig.6-14 Reference function in B-H graph

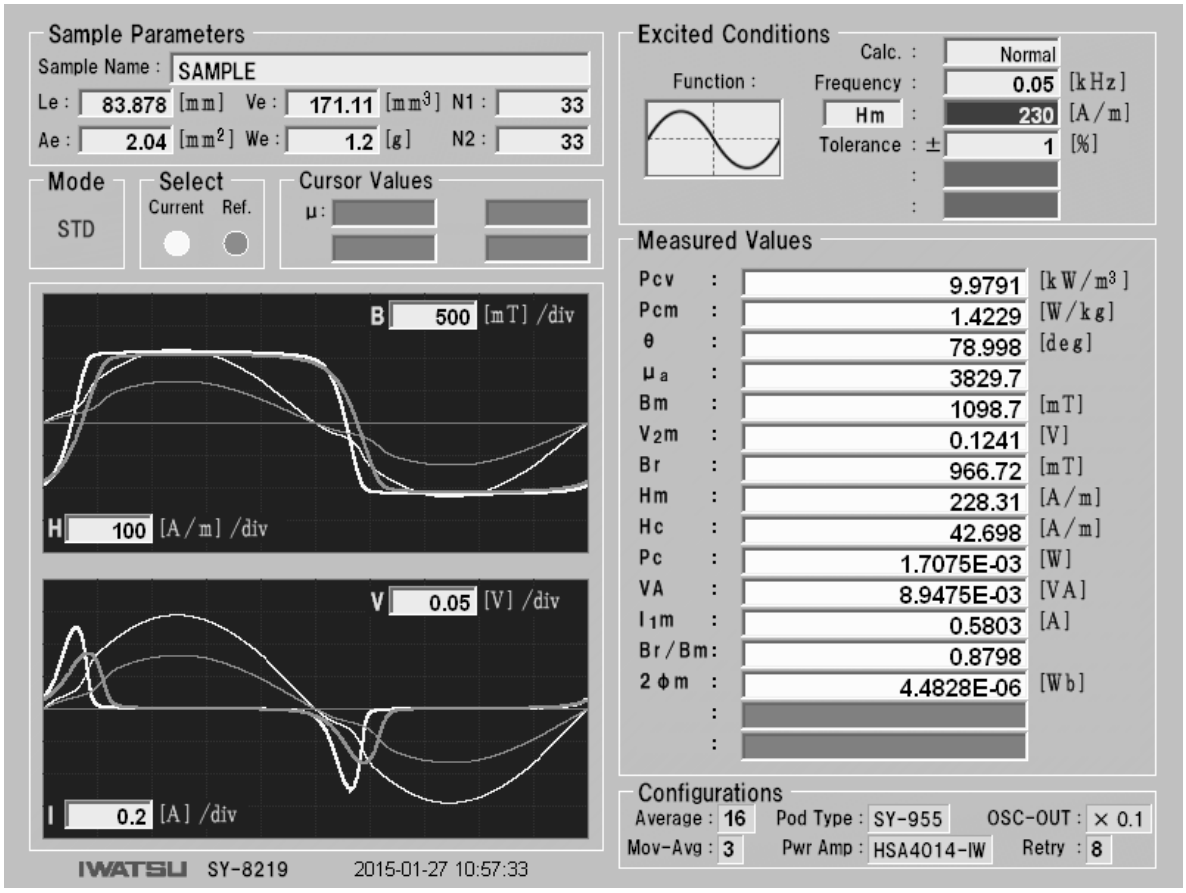


Fig.6-15 Reference function in time axis graph

■ 6.10 USB memory output of screen hardcopy

● A hardcopy of a measurement screen is generated to USB memory.

① Specify the file format of a screen hardcopy using **Print** on Utilities screen in advance (see the ■ 5.3 Setting of Print).

② Insert USB memory into USB port of this product.

③ When a measurement screen is displayed, press 

to display Save as screen.
(See Fig.6-16.)

④ Confirm the edition cursor on Target Equipment and press 

Popup List opens indicating drive of USB memory which is recognized by this product.
Move the edition cursor to the drive name to be generated and press 

to determine the drive for the output destination.

At that time, Save as screen displays the folder and the file on route of the determined USB memory
(See Fig.6-17.)

* The folder and the file where things except the character that can be input to the name with ten keys are included **cannot be displayed.** However, only _ (underscore) can be displayed.

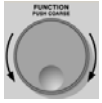
● If output is made with a new name added on the route
Here, how to store F:¥SAMPLE2.jpg is explained.

⑤ In the status shown in Fig.6-17, move the edition cursor to File Name (see Fig.6-18).

⑥ Press 

to open Popup Edit Box in which a file name*6-7 is entered. Use the ten key to enter the file name consisting of alphanumeric characters. To change the input location, press  to move the edition cursor.

To change a alphanumeric character, press  to move the edition cursor to the character and press  .

Or, rotate  to change the alphanumeric character.

Finally press 

to close Popup Edit Box and determine the file name.

* **6-7**: The file name consists of **up to 30 characters including 4 characters for extension**.

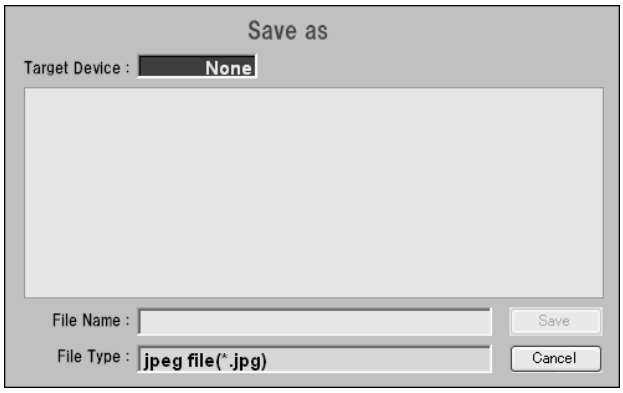


Fig.6-16 Save As screen

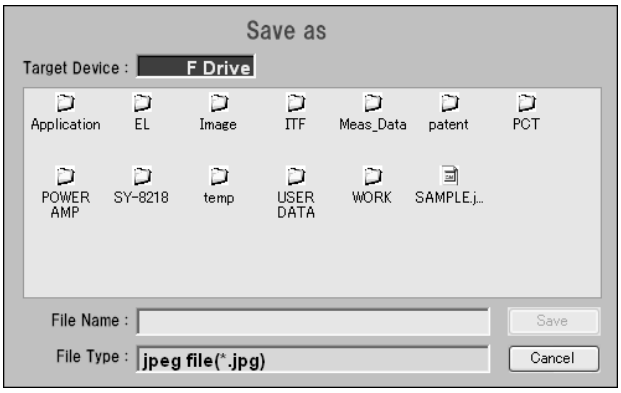


Fig.6-17 Save As screen

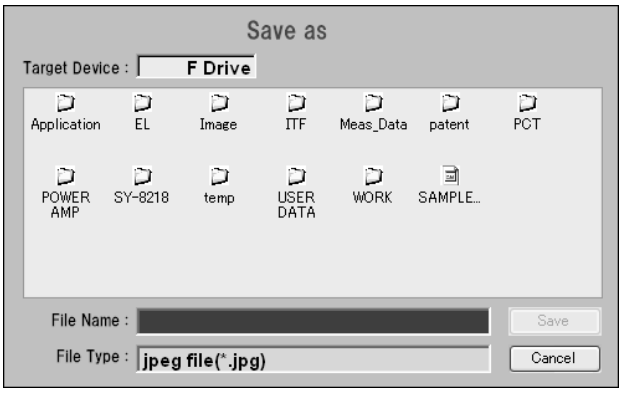


Fig.6-18 Save As screen

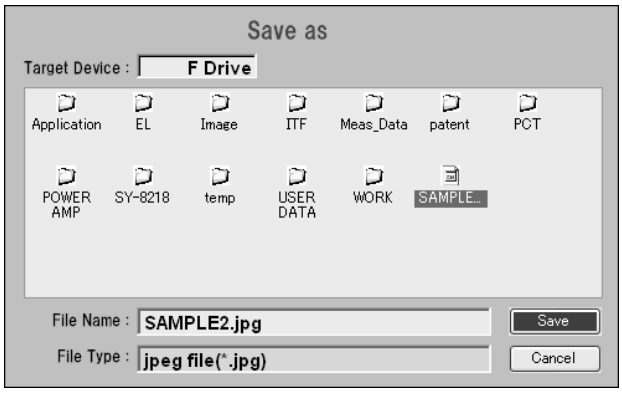
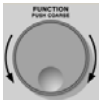


Fig.6-19 Save As screen

⑦ Press  or rotate  to move the edition cursor to Save button (see Fig6-19), and press 

to generate the screen hardcopy with the file name being set (SAMPLE2.jpg) on the route and to close Save as screen.

* Do not remove USB memory from the USB port during Save operation. **A file cannot be generated normally**.

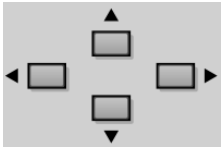
● If output is made with a new name added in the existing folder

Here, how to store F:¥Meas_Data¥SAMPLE3.jpg is explained.

⑧ In the status shown in Fig.6-17, move the edition cursor to the file display area (see Fig.6-20).

⑨ Press 

to select the route as an output destination.

⑩ Press  to move the edition cursor to Meas_Data folder (see Fig.6-21).

⑪ Press 

to display the folders and the files in Meas_Data folder (see Fig.6-22).

⑫ Press 

to move the edition cursor to the file display area (see Fig.6-23).

⑬ Press  to move the edition cursor to File Name and press 

to open Popup Edit Box to enter the file name.

If the same operation as ⑥ to ⑦ is made, the screen hardcopy with the file name being set (SAMPLE3.jpg) is generated in the specified folder and Save as screen is closed (see Fig.6-24).

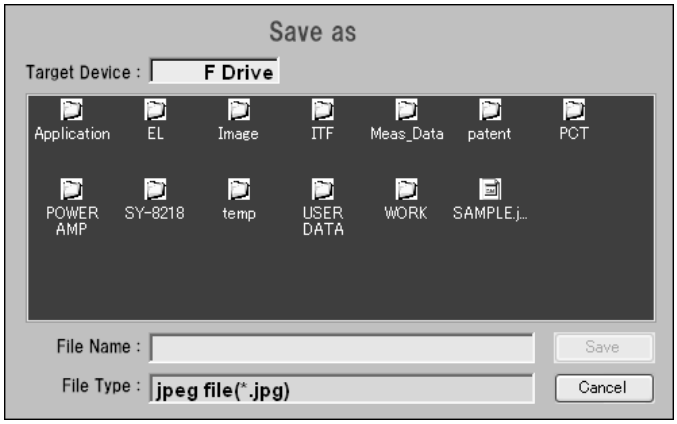


Fig.6-20 Save As screen

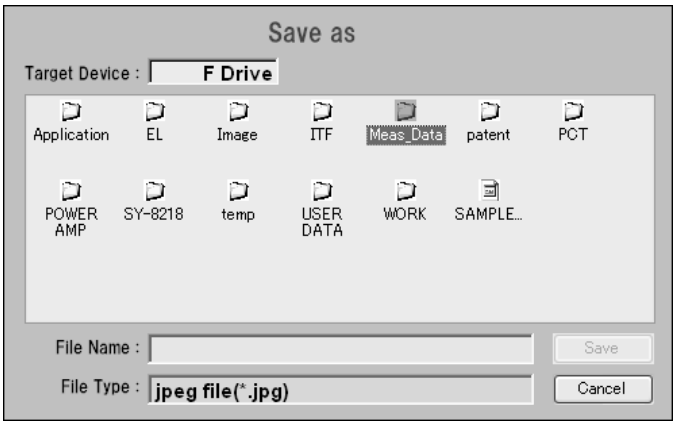


Fig.6-21 Save As screen

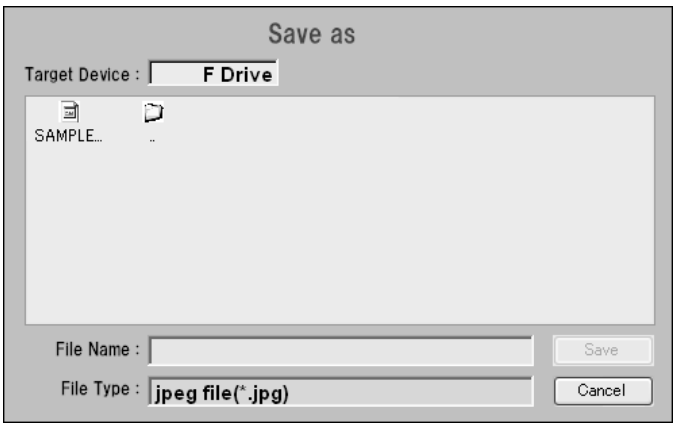


Fig.6-22 Save As screen

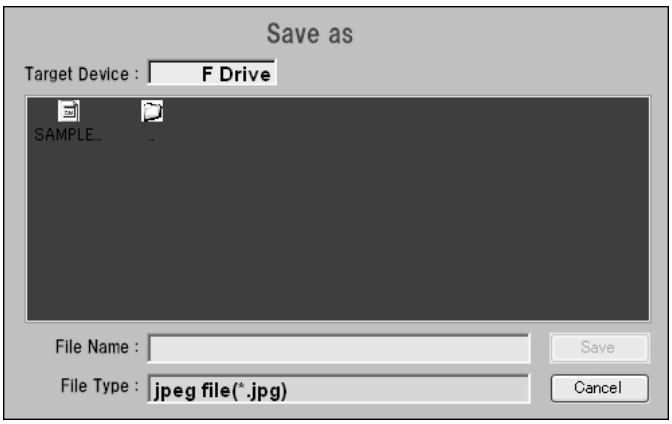


Fig.6-23 Save As screen

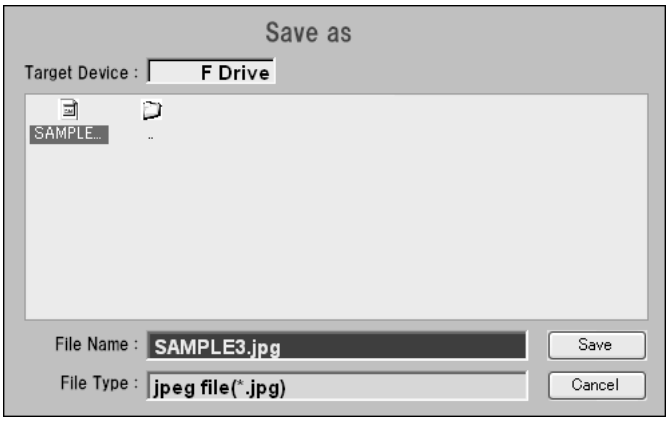


Fig.6-24 Save As screen

- If output is made overwriting the existing file

  As shown in Fig.6-25, when the edition cursor moves on the existing file, the file name is displayed on File Name column.

  Press 

to move the edition cursor to File Name column.

  If the same operation as ⑦ is made, Save operation is done so that the existing file is overwritten.

  * At this time, "W68" is displayed. When "Yes" is selected, the superscription is carried out. When “No" are selected, the superscription is canceled.

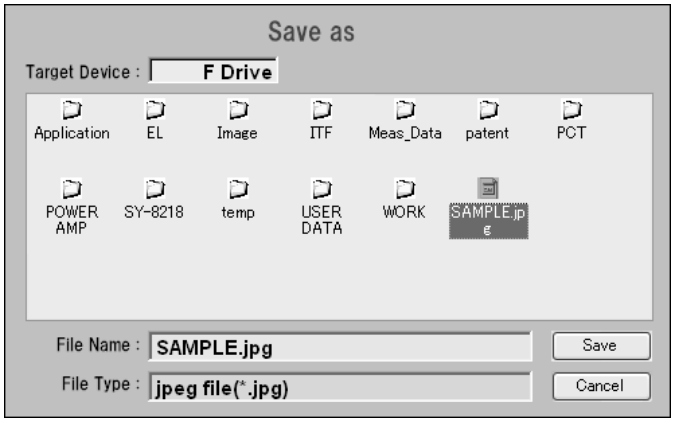


Fig.6-25 Save As screen

- If you want to return to upper folder

  If you want to return to the upper file when deciding the file output destination, move the edition cursor to the folder showing a file name using "…" and press 

to return to the upper file, as shown in Fig.6-26.

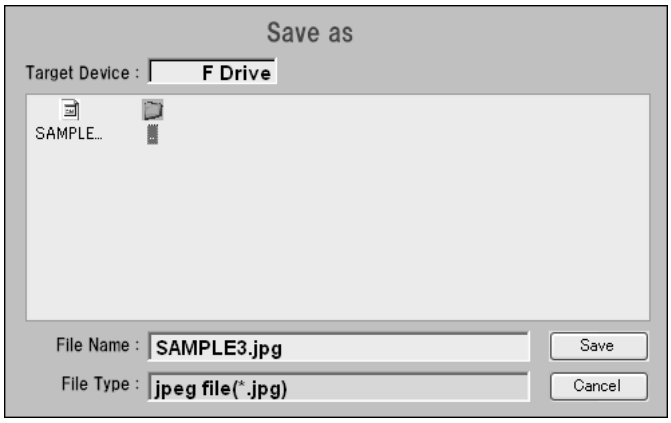


Fig.6-26 Save As screen

■ 6.11 Save/ recall of data

- This product can save measurement data and the like in the USB memory as shown in Table6-7. And it can recall the data from the USB memory.

Table 6-8 Save/ recall of data

Function	Type	Objective	File format	Extension	Description
Save (storage)	Setup	Only measurement condition	*6-8 Delimited by tab CSV format	.set	Only measurement condition is saved.
	Data	Measurement condition and measurement data		.mes	The measurement condition and Current*6-9 waveform measured under that condition are saved.
Recall (reading out)	Setup	Only measurement condition	Delimited by tab CSV forma	.set	The measurement condition is read out and is set for this product.
	Data	Measurement condition and measurement data		.mes	The measurement condition and measurement data are read out, the measurement conditions set for this product and the measurement data is displayed as Current waveform.

⚠ * **6-8**: **Never alter the content of the save file**. If an altered file is read out resulting in wrong operation or failure, this product **shall not be guaranteed and repaired**.

* **6-9**: Reference waveform (Storage waveform) **cannot be saved**. In addition, if a measurement condition is changed and no measurement is made under the changed condition, the measurement data **cannot be saved**. Only the measurement condition can be saved.

① Insert the USB memory into the USB port of this product.

② When 

is pressed while the measurement screen appears, selection menu for Save/Recall is displayed.
(See Fig.6-27.)

Fig.6-27 Save/Recall selection menu

③ Move the edition cursor to a desired function and press 

or press 
to display selection menu of Setup/Data (see Fig.6-28).

Fig.6-28 Setup/Data selection menu

Press of  allows the screen to return to selection menu for Save/Recall.

④ Move the edition cursor to a desired data type and press 

to display the corresponding Save As screen.
(See Fig.6-29)

⑤ Operation after this step is the same as "■6.10 USB memory output of screen hardcopy."

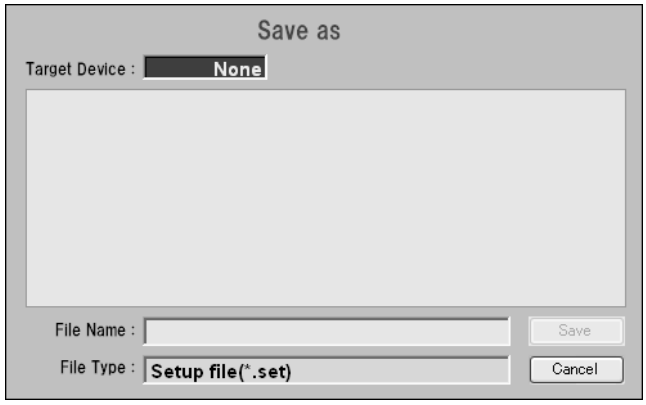


Fig.6-29 Save As screen for Setup

* Never remove the USB memory from the USB port during Save/Recall operation. A file **should not be generated normally**.

Chapter 7 Troubleshooting and Maintenance

■ 7.1 Error messages and warning messages

- If an error message or a warning message shown in Table 7-1 is displayed on the screen of this product, remedy described in the Table 7-1 should be made.

Table 7-1 Error / warning messages

Displayed messages	Causes	Remedies
E08: Call service!	• Interference of firmware when starting.	• Restart according to ■ 4.7. When the symptom is the same even if it restarts, **contact Iwatsu service center to tell the error message No.**
E01, **E02**, **E03**, **E05**, **E07**, **E11**: Call service!	• A malfunction occurs in hardware.	• Restart this product. When the symptom is the same even if it restarts, **contact Iwatsu service center to tell the error message No.**
In case of SY-8218, **E12**: POD unconnected! Shutdown the SY-8218! In case of SY-8219, **E12**: POD unconnected! Shutdown the SY-8219!	• A measurement POD is not connected to this product. • The model No. of a measurement POD connected to this product is different from that selected in measurement modes.	• Power off this product and connect a measurement POD to this product. • Power off this product and connect a proper measurement POD. * **If correspondence Option of Utilities > Option is not Enabled, it is not possible to measure.**
E13: Memory bank X data has NaN!	• Non-numerical value is written in memory bank X, or memory bank X is abnormal.	• Restart this product. When the symptom is the same even if it restarts, **contact Iwatsu service center to tell the error message No.**
E14: Memory bank X shunt resistance errors!	• The shunt resistance of memory bank X is ≦0.	
E16: SY-821x software version is outdated!	• As the version of the software for the B-H Analyzer is old, it doesn't correspond to SY-810 used.	**The main unit software should improve in the version. Contact Iwatsu service center.**
E17: Temp. of FET heat sink on DCS exceeds setting!	• The temperature(thermistor) of the heat sink of SY-961(DCS) exceeded 90℃.	• Restart SY-961. When the symptom is the same even if it restarts, **contact Iwatsu service center to tell the error message No.**
E18: DCS over current!	• The output current of SY-961(DCS) exceeded setting value ×1.1.	• Power off SY-961. **Contact Iwatsu service center to tell the error message No.**
W09: Measurement was finished forcibly!	• STOP button is pressed to stop measurement forcibly.	—
W12: Temp. of the shunt resistance exceeds setting!	• The temperature of the shunt resistance measuring the exciting current exceeds 80℃.	• Reduce Hm, Bm, I_1m, and V_2m specified in Fixed Parameter to decrease the exciting current before measurement. • Reduce the number of Averages. Or increase Tolerance to make the excitation time short.
W13: Pod cover opens!	• POD cover opens. • POD is removed from the main unit.	• Close POD cover securely. • Power off this product and install POD on the main unit securely.
W14 : Shortage of the exciting current!	• The exciting current is insufficient by approximate value excitation. • The DC cable (black) has been disconnected by the DC bias measurement.	• Confirm whether the sample is connected. • Confirm whether the output has gone out of the power amplifier. • Raise the gain of the power amplifier. • Increase N_1 of the sample. • Confirm the disconnection of the DC cable (black).
W15: SST cover opens!	• The cover of SY-956 (SST) is open.	• Shut the cover of SY-956 neatly.
W16: DCT cover opens!	• The cover of SY-960 (DCT) is open.	• Shut the cover of SY-960 neatly.

Table 7-1 Error/ warning messages

Displayed messages	Causes	Remedies
W19: H range over at 1st excitation!	• Overflow occurs in the exciting current measurement range during approximate value excitation.	• If Hm is specified in Fixed Parameter, confirm that numeric values and units of Le and N_1 are correct.
W20: B range over at 1st excitation!	• Overflow occurs in the induced voltage measurement range during approximate value excitation.	• If Bm is specified in Fixed Parameter, confirm that numeric numbers and units of Ae and N_2 are correct.
W23: SST serial communication is abnormal!	• Serial communication with SY-956 (SST) is abnormal.	• Restart this product and SY-956. When this phenomenon happens frequently, **contact Iwatsu service center to tell the error message No.**
W24: DCT serial communication is abnormal!	• Serial communication with SY-960 (DCT) is abnormal.	• Restart this product, SY-960 and SY-961. When this phenomenon happens frequently, **contact Iwatsu service center to tell the error message No.**
W25 : DCS serial communication is abnormal!	• Serial communication with SY-961 (DCS) is abnormal.	• Restart this product, SY-960 and SY-961. When this phenomenon happens frequently, **contact Iwatsu service center to tell the error message No.**
W30: Setting condition error! V2 > 200V	• In measurement condition, induced voltage exceeds 200[V].	• Confirm that values and units of N2, Ae, freq. are proper. • Confirm that values and units of Bm specified in Fixed Parameter is proper. • Reduce N2 of the sample.
W32: Setting condition error! I1 > 6A	• In measurement condition, exciting current exceeds 6[A].	• Confirm that values and units of N_1 and Le are proper. • Confirm that value of Hm specified in Fixed Parameter is proper. • Increase N_1 of the sample.
W34: Setting condition error! Yoke V3 or V4 > 200V	• It is forecast that the output voltage of the third or fourth turns of the measurement yoke exceeds 200V when 2nd is measured by the Single Seat Measurement.	• Confirm whether the value specified with Fixed Parameter is too large. • Confirm whether the value of Ae is too large.
W35: Setting condition error! ⊿VL > 400V	• It is a measurement condition for the increment voltage to exceed $400V_{p\text{-}p}$ by the DC bias measurement.	• Confirm that values and units of N2, Ae, freq. are proper. • Confirm that values and units of Bm specified in Fixed Parameter is proper. • Reduce N2 of the sample.
W36: Setting condition error! ⊿IL > 12A	• It is a measurement condition for the increment current to exceed $12A_{p\text{-}p}$ by the DC bias measurement.	• Confirm that values and units of N_1 and Le are proper. • Confirm that value of Hm specified in Fixed Parameter is proper. • Increase N_1 of the sample.
W41: OSC output under! ≤ 0V	• OSC output is tried to be set under 0V during approximate value excitation.	• Confirm whether the value specified with Fixed Parameter is too small. • Reduce the gain of the power amplifier.
W42: Shortage of the exciting current!	• The exciting current is insufficient by asymptote excitation.	• Confirm whether the sample is connected or disconnected.
W43: OSC output under! ≦ 0V	• OSC output is tried to be set under 0V during asymptote excitation.	• Confirm whether the output of the power amplifier is proper. • Reduce the gain of the power amplifier.
W50: Measured V2m over! > 200V	• Induced voltage measured exceeds 200[V].	• Confirm that values and units of N_2, Ae, and freq. are proper. • Confirm that value and unit of Bm specified in Fixed Parameter are proper. • Reduce N_2 of the sample.

Table 7-1 Error/ warning messages

Displayed messages	Causes	Remedies
W51: Measured V2m under! ≦ 0V	• Induced voltage measured becomes 0[V] or less.	• Confirm whether the output of the power amplifier exceeds ratings.
		• Confirm whether secondary turns has been disconnected.
W52: Measured I1m over! > 6A	• Exciting current measured exceeds 6[A].	• Confirm that values and units of N_1 and Le are proper.
		• Confirm that value and unit of Hm specified in Fixed Parameter are proper.
		• Increase N_1 of the sample.
W53: Measured I1m under! ≤ 0A	• Exciting current measured is under 0[A].	• Confirm that value and unit of specified in Fixed Parameter are proper.
		• Confirm that primary turns has not been disconnected.
		• It is an extremely small current that cannot be measured with this product.
W54: Measured VL over! > 200V	• In DC bias measurement, the voltage to be measured exceeds 200[V].	• Confirm the measurement condition. (Refer to section 2.3 of the instruction manual for SY-960.)
W55: DCS overvoltage!	• The compliance voltage of SY-960 (DCS) is overvoltage.	• After confirm whether big Idc is thrown into the sample that ESR is big, restart SY-961.
W56: DCS no current!	• The current is not output from SY-961(DCS).	• After confirm whether the DC cable disconnects or unconnects, restart SY-961
W57: Temp. of FET heat sink on DCS exceeds setting!	• The temperature (IC sensor) of the heat sink of SY-961(DCS) exceeded 90℃.	• Restart SY-961. When this phenomenon happens frequently, **contact Iwatsu service center to tell the error message No.**
W58: Temp. of sample on DCT exceeds setting !	• The temperature of the sample exceeded the preset temperature of overheating protection switch by the DC bias measurement while measuring.	• Review the measurement condition.
W59: Measured ⊿IL over! > 12A	• It is a measurement condition for the increment current to exceed $12A_{p\text{-}p}$ by the DC bias measurement.	• Confirm the measurement condition. (Refer to section 2.3 of the Instruction Manual for SY-960.)
W60: Retry over!	• In the number of excitation times set in Configuration > Retry, a measured value of the parameter specified in Fixed Parameter cannot be obtained within Tolerance.	• Try to increase Tolerance.
		• Enlarge the value specified with Fixed Parameter.
		• Increase the number of Retry times.
		• If B-H curve becomes nearly saturated, change Fixed Parameter from Bm to Hm.
W61: Accuracy limit of measurement!	• The minimum limit of core loss measured by this product is exceeded.	• Confirm broken winding and winding applied to the measurement POD.
		• Extremely small core loss that cannot be measured with this product
Especially, when NaN or Inf is included in measured value	• The sample that should be measured with 1-coil method is measured with 2-coil method.	• Measure with 1-coil method.
W62: Not measure in this condition!	• Although a measurement condition is changed, no measurement is made and data tries to be saved.	• After measurement, save the data.

Table 7-1 Error/ warning messages

Displayed messages	Causes	Remedies
W63: C drive cannot save!	• Data or setup tries to be saved in C drive.	• Connect USB memory to this product and save data in it. * **This product does not disclose C drive to a user.**
W65: Target equipment is not found!	• No storage equipment to save / recall is found out (removed on the way).	• Press the EXT key and then insert USB memory to save / recall data.
	• Recalled the data of a different model.	• The data of a different model can not be recalled.
W66: Read only file cannot be saved!	• Data cannot be saved in the read-only file.	• Specify other than read-only file for a storage file.
W68: Already exits. Do you want to overwrite it?	• Data tries to be overwritten on an existing file.	• Select Yes or No.
W69: Failed in a saved!	• Data fails to be saved. (Memory is full or memory is removed during save operation.)	• Remove the cause.
W70: Failed in a recalled!	• It failed in the recall of data. (SST that doesn't correspond to the main unit is connected and so on.)	• Remove the cause.
W71: DCS output time out!	• The electric current output time of SY-961(DCS) exceeded the time limit.	• Try to increase Tolerance.
		• Decrease the number of Retry times.
i01: B Coil has been changed. Please enter the N2!	• Because B coil was changed to User by the Single Seat Measurement, it is urged to input N2.	• Input the value of N2.
i02: B Coil has been changed. Press the EXIT key to start!	• It is informed that the kind of B coil of the attachment was changed by the Single Seat Measurement.	• Press the EXIT key to continue the measurement.

■ 7.2 Measurement results

● If the result of measurement on this product shows the phenomenon shown in Table 7-2, it may be improved when remedies described in the Table 7-2 are made.

Table 7-2 Measurement results

Phenomena	Causes	Remedies
Right/ left or top/ bottom of B-H curve are reversed.	• Wrong wiring of start. / end of the primary/ secondary turns to the measurement POD.	• Make correct wiring; * **Start of winding to + side, end to - side.**
B-H curve is not symmetry.	• DC offset is superimposed on the output of the power amplifier.	• Adjustment is made so that offset of the power amplifier is set to 0. • Reduce the gain of the power amplifier.
		• Connect the provided AC couple module to the output of the power amplifier. * **It cannot be used for measurement less than 10[kHz]. When the frequency less than this is necessary, it is possible to measure by using LF AC COUPLER SY-514.**
	• OSC cable SY-911 for IE-1125 is not connected though the power amplifier used is IE-1125x.	• Connect OSC cable SY-911 for IE-1125.
Under nearly saturated measurement condition of B-H curve, core loss values disperse.	• Measurement is made with Fixed Parameter specifying Bm. (If B-H curve is nearly saturated, reduce Tolerance and specify Bm for Fixed Parameter. In such a way, small amount of difference of Bm measurement values causes core loss values to disperse greatly.)	• Change the measurement mode to specify Hm for Fixed Parameter.
If the number of turns changes, a core loss value changes greatly.	• The inductance of a sample resonates with the input capacitance of this product.	• Reduce the inductance of the sample. Or reduce the measurement frequency. (See ■ 4.4 Winding of a sample.)
The value of the core loss varies by the measurement day though it is the same sample.	• The magnetic characteristic of the sample changes at the temperature.	• Always measure at the same temperature. * **It is possible to measure with Chamber Scanner System SY-320x/321x.**
	• The stability of the magnetic characteristic of the sample is bad.	• A change with the lapse of time of the magnetic characteristic is measured, and confirmed. * **It is possible to measure with Continuous Measurement Function SY-811.**
	• The contact of Chamber Scanner System has been worn out.	• Observe the wear-out condition of contact SY-512, and exchange it if necessary.

■ 7.3 Others

● If the operation on this product shows the phenomenon shown in Table 7-3, it may be improved when remedies described in the Table 7-3 are made.

Table 7-3 Others

Phenomena	Causes	Remedies
If this product is started by pressing POWER switch, it stops on the way of BIOS screen; i.e. it cannot start.	• USB equipment is connected to USB port.	• This product can not normally start if USB equipment is inserted in the USB port. Remove the USB equipment from the USB port and restart this product.
Operation cannot be done on the operation panel.	• This product hangs up for some reason.	• Power off the main power switch on the rear of this product, wait for 15[sec] or more, restart this product.

■ 7.4 Cleaning

- To clean dirt on the outer surface of this product and the cover of the measurement POD, gently wipe them with soft cloth moistened with a small quantity of neutral detergent. Never use organic solvent. If used, discoloration or corrosion may occur.

■ 7.5 Calibration

- Long time use may cause the measurement accuracy of this product to fluctuate, depending on use environment or frequency. Calibration at least once a year is recommended. For details, contact Iwatsu office or our sales distributors.

Chapter 8 Specifications

■ 8.1 Oscillator output

Oscillation frequency	: Sine wave 10 Hz to 10 MHz (SY-8218), 10 Hz to 1 MHz (SY-8219)
	: Square wave (Duty: 50 %, symmetry) 10 Hz to 1 MHz
Frequency accuracy	: ±0.2 % or less
Distortion factor	: 2 % or less
Output amplitude	: Max. approx. ±3.2 V (50 Ω load, 100 kHz)
Output resistance	: Approx. 50 Ω
Output attenuator	: 1/1, 1/2, 1/5, 1/10

■ 8.2 Signal detector (SY-951 / SY-955)

Exciting current detector (H-CH)	
Detection resistance	: Approx. 1 Ω
Detection sensitivity (full scale)	: ±5 mA, ±10 mA, ±20 mA, ±50 mA, ±100 mA, ±200 mA, ±500 mA, ±1 A, ±2 A, ±5 A, ±10 A
Max. input permissible current	: ±6 A
Induced voltage detector (B CH)	
Detection sensitivity (full scale)	: ±5 mV, ±10 mV, ±20 mV, ±50 mV, ±100 mV, ±200 mV, ±500 mV, ±1 V, ±2 V, ±5 V, ±10 V, ±20 V, ±50 V, ±100 V, ±200 V
Max. input permissible current	: ±200 V
Input resistance	: Approx. 1 MΩ
Input capacitance	: Approx. 18.5 pF (between S2-S1 terminals)
AD converter	
Sampling rate	: 50 MS/s (Max.)
Resolution	: 16 bit

■ 8.3 Measurement accuracy

Phase	: ±0.15 deg (Typical value, f =100 kHz, 50 mA, 50 mV range or more, at the amplitude of 80 % or more of used range)
Amplitude	: ±2 % (Typical value, f=1 kHz, 50 mA, 50 mV range or more)
Core loss	: ±5.6 % (Typical value, estimated value for θ=80 °, f = 100 kHz, 50 mA, 50 mV range or more)

■ 8.4 Measurement

Calculation mode

Types : Normal mode, μ mode

Functions : Functions in each calculation mode are in accordance with table below:

	Normal **mode**	**μ mode**
Function	With a frequency fixed, up to a setting target value*1, and when it is reached, make measurement under conditions at that time, and the property value is calculated by using the 100th high harmonic of the measuring frequency.	With a frequency fixed, up to a setting target value*1, and when it is reached, make measurement under conditions at that time, and the property value is calculated by using the fundamental wave element of the measuring frequency excluding part.
Measurement frequency	SY-8218 sine wave: 10 Hz to 10 MHz SY-8219 sine wave: 10 Hz to 1 MHz Square wave (Duty50 %, symmetry): 10 Hz to 1 MHz	SY-8218 sine wave: 10 Hz to 10 MHz SY-8219 sine wave: 10 Hz to 1 MHz

* 1 A target value is the range which is obtained by multiplying Hm, I_1m, Bm, or V_2m being set by Tolerance.

Measurement waveform

Exciting current, induced voltage, magnetic field (intensity), magnetic flux density, B-H curve

Characteristics values

They depend on calculation modes and are in accordance with table below. The symbol to which * adheres is calculated from the fundamental wave element.

Calculation modes	Normal mode			μ mode		
	Symbol	Typical unit	Meaning	Symbol	Typical unit	Meaning
Measurement values	Pcv	[W/m^3]	Core loss per volume	Bm	[T]	Max. magnetic flux density
	Pcm	[W/kg]	Core loss per mass	V_2m	[V]	Max. induced voltage
	θ	[deg]	Phase angle	Hm	[A/m]	Max. magnetic field
	μ_a	—	Relative permeability	I_1m	[A]	Max. exciting current
	Bm	[T]	Max. magnetic flux density	μ_a	—	Relative permeability
	V_2m	[V]	Max. induced voltage	*L	[H]	Inductance
	Br	[T]	Residual magnetic flux density	*R	[Ω]	Resistance
	Hm	[A/m]	Max. magnetic field	*|Z|	[Ω]	Impedance
	Hc	[A/m]	Coercive force	Pc	[W]	Core loss
	Pc	[W]	Core loss	*μ′	—	Complex permeability (real part)
	VA	[VA]	Apparent power	*μ″	—	Complex permeability (imaginary part)
	I_1m	[A]	Max. exciting current	*μ_z	—	Impedance permeability
	Br/Bm	—	Rectangular ratio	*θ	[deg]	Phase angle
	2Φm	[Wb]	Total flux linkage	*Q	—	Quality coefficient
	—	—	—	*tanδ	—	Loss coefficient
	—	—	—	THD	[dB]	Total harmonic distortion

Reference function

It remembers a measurement condition, a characteristics value, and measurement waveform data (for each time of measurement).

Cursor measurement

Cross, Grad

Graph display

B—t, H—t, V-t, I-t, B—H

Setting items and setting range

They are in accordance with table below:

Category	Setting items		Setting range	
Unit	Le (effective length of magnetic path)		any of mm, cm, and m	
	Ae (effective net core area)		any of μm^2, mm^2, cm^2 , and m^2	
	Ve (effective net volume)		any of mm^3, cm^3, and m^3	
	We (effective weight)		either of g and kg	
	Freq.(measurement frequency)		any of Hz, kHz, and MHz	
	B (magnetic flux density)		either of mT and T	
	Pc (core loss)		either of mW and W	
	Pcv (core loss per volume)		any of W/m^3, kW/m^3, and mW/m^3	
	Pcm (core loss per mass)		any of W/kg, W/g, and mW/g	
	L (inductance)		any of μH, mH, and H	
	I_1m (exciting current)		either of mA and A	
	V_2m (induced voltage)		either of mV and V	
Information (equipment information)	Sound		either of On and Off	
	Warning		either of On and Off	
	Date		2000-01-01 - 2099-12-31	
	Time		00:00:00 - 23:59:59	
Print (screen print)	File Format		either of jpg and png	
Measuring Method	Average (number of average cycles)		a power of 2 of 2^0 - 2^6 (any of 1, 2, 4, 8, 16, 32, and 64)	
	Retry (number of retry cycles		a power of 2^3 - 2^5 (any of 8, 16, and 32)	
	Mov-Avg (moving average cycles)		an odd number in 1 to 111	
	Coil (method of turns)		either of 1 and 2	
	Fixed Parameter (target parameter)		any of B_m, H_m, I_{1m} and V_{2m}	
Setting of Equipment	Power Amp (used power amplifier)		any of IE-1125, IE-1125A, IE-1125B, HSA4014-IW, HSA4052-IW, HSA4101-IW, Other, and Not Used. However, if Other is selected, arbitrary 10 characters can be entered.	
	Power Amp Gain (power amplifier gain)		an integral number in 1 - 100	
	Pod (model number of measurement POD selected by measurement mode) * POD that can be selected depends on the installing option.		SY-8218	any of SY-951(Standard), SY-32x(Chamber), SY-956(Single Sheet), and SY-960(DC Bias)
			SY-8219	any of SY-955(Standard), SY-32x (Chamber), SY-956(Single Sheet), and SY-960(DC Bias)
	BW for Pulse (band limitation of pulse waveform)		any of Off, 100 ns, and 200 ns	
Measurement	Sample Name		Up to 20 characters	
	Le, Ae, Ve, We		0.001 to 99999	
	N1 (No. of primary turns), N2(No. of secondary turns)		0.1 to 9999.9	
	Function (signal type)		either of Sine and Pulse (however, Pulse not for μ mode)	
	Frequency (signal frequency)	Sine	SY-8218	2 digits for 10 Hz to 10 MHz and 99 Hz or less, upper 3 digits for 100 Hz or more can be set.
			SY-8219	2 digits for 10 Hz to 1 MHz and 99 Hz or less, upper 3 digits for 100 Hz or more can be set.
		Pulse	2 digits for 10 Hz to 1 MHz and 99 Hz or less, upper 3 digits for 100 Hz or more can be set.	
	Hm, I_1m, Bm, V_2m		0.001 to 99999	
	Tolerance (measurement permissible error)		0.1 to 100	

Category	Setting items	Setting range
Graph	H[A/m]/div	any of Reset, 0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000, 5000 and 10000
	B[mT]/div	any of Reset, 0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, 500, and 1000
	I[A]/div	any of Reset, 1E-6, 2E-6, 5E-6, 10E-6, 20E-6, 50E-6, 100E-6, 200E-6, 500E-6, 0.001, 0.002, 0.005, 0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 1, 2, and 5
	V[V]/div	any of Reset, 1E-6, 2E-6, 5E-6, 10E-6, 20E-6, 50E-6, 100E-6, 200E-6, 500E-6, 0.001, 0.002, 0.005, 0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, and 100

■ 8.5 SYNC OUT

Output level : Approx. 3.3 V (for 50 Ω termination)

■ 8.6 Display equipment

Method : 8.4 type TFT-LCD
Resolution : SVGA 800×600 pixel

■ 8.7 External memory

USB memory : Up to 5 USB2.0 memories, save/ recall of measurement conditions, save/ recall of measurement data, save of screen hard copy

■ 8.8 Power supply

Power supply input range : 100-240 VAC, 50/60 Hz
Power consumption : 130 VA (Max.)
Standby power consumption : Approx. 15 VA (at 100 V) / approx. 25 VA (at 240 V) (only when main power SW is ON on the rear)

■ 8.9 Mechanical

Outside dimensions : 420(W) ×480(D) ×266(H) (tolerance: ±2 mm, accessories and projection not included)
Mass : B-H Analyzer main unit: approx. 12.5 kg (accessories and options not included)
: Standard measurement POD: approx. 1.7 kg (options not included)

■ 8.10 Environmental conditions

Operation/ specifications guaranteed range : operation +5 °C to +35 °C specifications 23 °C±5 °C
Operation guaranteed humidity range : 85 % RH (+35 °C, non-condensation)
Warming up time : Specification standard uses guaranteed values 30 minutes after powering on.
Storage temperature : –20 °C to 60 °C (5 % to 85 %, non-condensation)

■ 8.11 Certification Standards

This instrument meets requirements of EMC Directive 2014/30/EU and Low Voltage Directive 2014/35/EU.

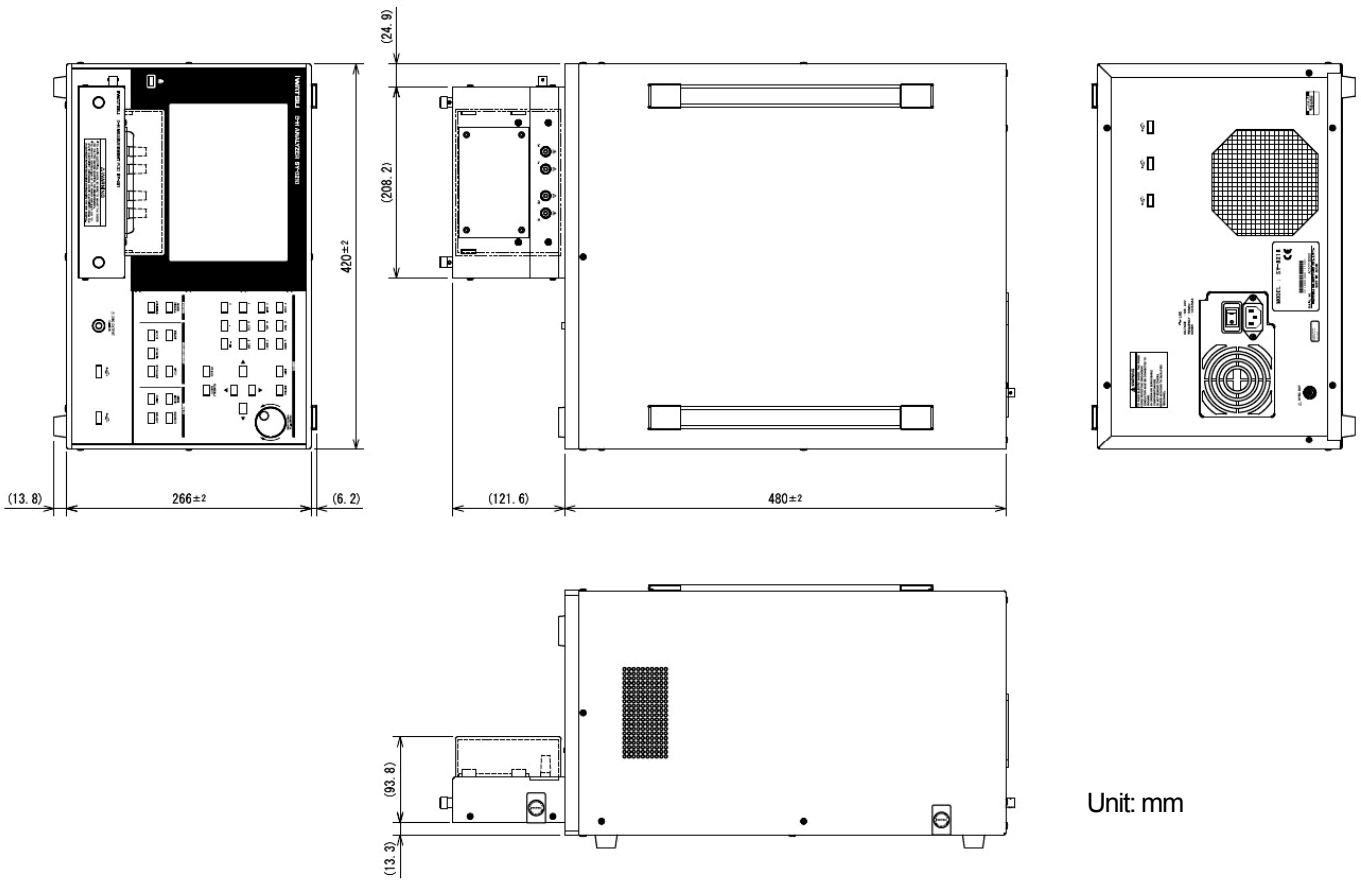
EMC Directive
Emission : EN 61326-1: 2013 (Class A)
: EN 61000-3-2: 2006+A1 :2009+A2 :2009
: EN 61000-3-3: 2008
Immunity : EN 61326-1: 2013

Low Voltage Directive
Safety : EN 61010-1: 2010 (Third Edition)
Overvoltage category : Ⅱ
Pollution degree : 2

■ 8.12 Accessories

Power cord (2.5 m, Un-shielded)
Cord strap
OSC cable (BNC-SMA 1 m, shielded)
Power amplifier cable (BNC-BNC 1.2 m, shielded)
AC couple module
Instruction manual (CD)
POD cover
User's guide

■ 8.13 Outside appearance diagram



Unit: mm

Chapter 9 Measurement Accuracy of Core Loss

■ 9.1 Phase angle θ and core loss Pc in distorted wave

- The following describes the relationship between the phase angle θ and the core loss Pc when a primary exciting current i_1 or a secondary induced voltage V_2 is a distorted wave.
  If a B-H curve enter a saturated area; i.e. a primary exciting current i_1 or a secondary induced voltage V_2 is a distorted wave, the relationship between the phase angle θ and the core loss Pc i**s not necessarily expressed as "When θ is large, Pc is small"** which is used at the time when i_1 and V_2 are the single sine wave and **it is proper to consider** that discussion of the core loss Pc using the phase angle θ is used **as a standard**.

Fig.9-1 shows the power vector. If a measured current and a measured voltage are the single sine wave, the phase angle θ can be expressed using the apparent power VA and the Active power (core loss) Pc, as shown in expression (2-14):

$$\theta = \cos^{-1}\left(\frac{P_c}{VA}\right) \qquad \text{(2.14): listed again}$$

It apparently shows "When θ is large, Pc is small).

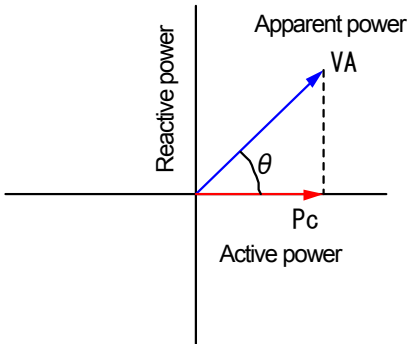


Fig.9-1 Phase angle of single sine wave

Next, consider the case where a measured current and a measured voltage are distorted wave; not single sine wave. It corresponds to the case where B-H loop enters a saturated area. The fact that the waveform of a current or voltage is distorted means that the wave includes other frequency ingredient than sine wave of a basic frequency. Consider the phase angel θ at that time.

Actually, a limitless number of frequency ingredients are included. However, to simplify the explanation here, assume that only one frequency ingredient in addition to a basic ingredient (hereinafter called "high-harmonic ingredient") is included.

Fig.9-2 is the vector diagram indicating the case where the apparent power of the basic wave is VA and the apparent power of the high harmonic wave is va. Generally, since a magnetic material has a different core loss and permeability in a different frequency from the basic wave, the direction and intensity of va is different from those of VA. The composed vector of va and VA is the apparent power VA of the distorted wave. The diagram apparently shows that the phase angel θ' at that time is larger than θ only for the basic wave.

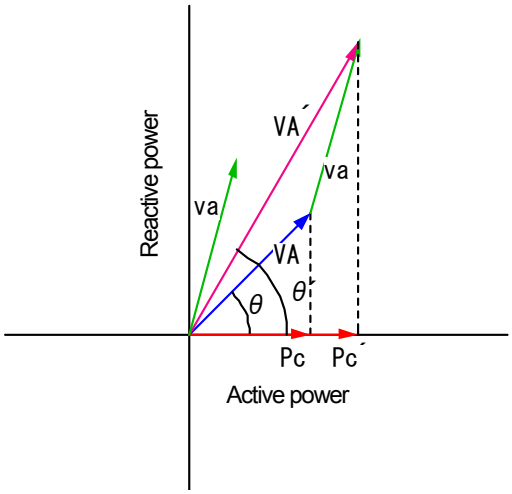


Fig.9-2 Phase angle of non-single sine wave (1)

Next, see another power vector diagram: i.e. Fig.9-3. The direction and intensity of va in this diagram are different from those in Fig.9-2, and as a result, the phase angle θ´ of the composed apparent power VA' is smaller than θ only for the basic wave.

In either case, the core loss Pc increases to Pc' but the increment of the phase angle is different from that only for the basic wave. It is considered that which type is used is determined by whether increment of the reactive power or the core loss only for the basic wave is larger than that for the high harmonic wave. The increment of the reactive power is considered to be controlled by the inductance (i.e. permeability) or capacitance. On the other hand, the increment of the core loss is considered to be controlled by hysteresis loss or eddy current loss.

As described above, if a B-H loop enters the saturated area; i.e, the single sine wave is not used for explanation, it is proper to consider that discussion of the core loss Pc using the phase angel θ is used as a standard.

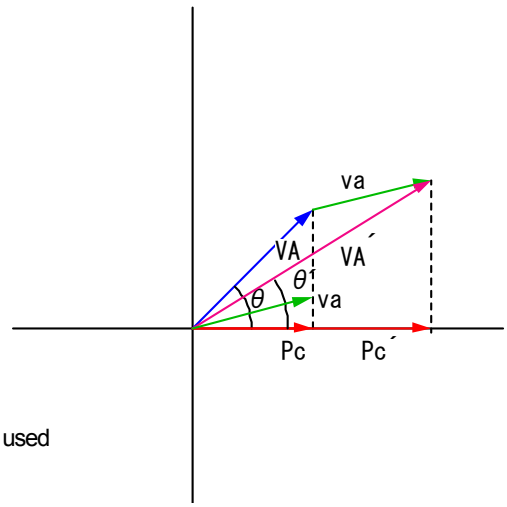


Fig.9-3 Phase angle of non-single sine wave (2)

■ 9.2 Relationship between measurement error of core loss Pc and phase angel θ (1)

- The following describes the relationship between the measurement error of the core loss Pc and the phase angle θ when a primary exciting current i_1 and a secondary induced voltage V_2 **are a single sine wave**.

As described in Section 9.1, if both a primary exciting current i_1 and a secondary induced voltage V_2 are a single sine wave, the fact that a phase angle θ is large is equal to the fact that a core loss Pc is small. As the phase angle θ becomes close to 90°, the measurement accuracy of the core loss Pc becomes worse. Finally, at θ=90°, the measurement accuracy of the **core loss Pc is dispersed and cannot be specified**. This cannot be escaped from the pure mathematical principle.

If both the primary exciting current i_1 and the secondary induced voltage V_2 are a single sine wave, effective values for both are i and V, and the phase angel between them is θ, the core loss Pc is expressed in expression 9.1):

$$P_c = i \cdot V \cdot \cos\theta \qquad (9.1)$$

The expression apparently shows that calculation of the core loss Pc includes ① amplitude measurement error of current and voltage and ② phase measurement error between current and voltage. The amplitude measurement error of ① is the same as the measurement error in a general current/ voltage instrument. The phase measurement error of ② is the relative phase difference of current or voltage waveform and corresponds to the time gap of the measured waveform.

Here, assume that real effective values of the current and voltage are i and V, the real value of the phase angle of a sample is θ. In addition, if each measurement error is ⊿i, ⊿V, or ⊿θ, the measurement error of the core loss is expressed by expression (9.2):

$$\Delta P_c = \frac{(i+\Delta i)\cdot(V+\Delta V)\cdot\cos(\theta+\Delta\theta) - i\cdot V\cdot\cos\theta}{i\cdot V\cdot\cos\theta}$$
$$= \frac{i+\Delta i}{i}\cdot\frac{V+\Delta V}{V}\cdot\frac{\cos(\theta+\Delta\theta)}{\cos\theta} - 1 \qquad (9.2)$$

The 1st term indicates the measurement error of the current, the 2nd term indicates that of the voltage, and the 3rd term indicates that of the phase. The core loss measurement error ⊿Pc is more controlled by the 3rd term as the phase angle θ is closer to 90°.
Fig.9-4 shows the core loss measurement error when the phase measurement error ⊿θ varies within the range of ±0.4° at the phase angel of θ=89.0° – 89.8° (amplitude measurement error not included). For example, when the phase angle is θ=89.6°, the core loss measurement error can be 50% when the phase measurement error is 0.2°

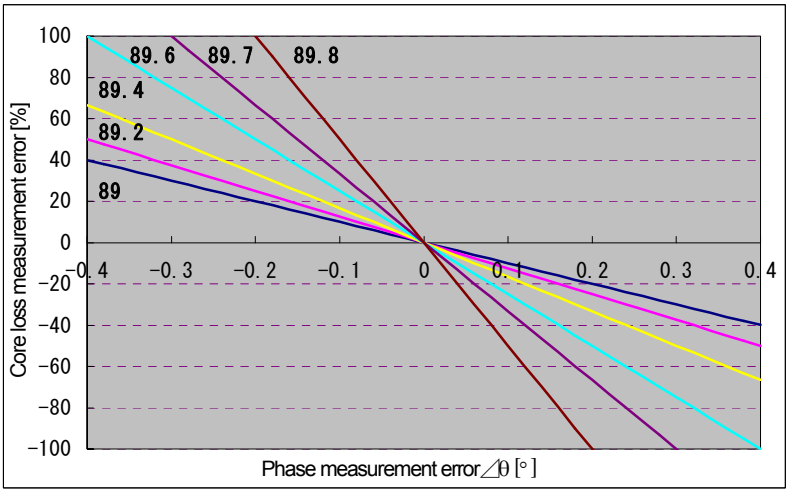


Fig.9-4 Phase measurement accuracy and core loss measurement error for single sine wave

It can be easily understood that for the same phase measurement error⊿θ, the core loss measurement error is dispersed closer to ∞ as the real value θ become close to 90°.
Even if both the primary exciting current i_1 and the secondary induced voltage V_2 are the single sine wave, it is very difficult to measure the **core loss Pc with high accuracy in the higher phase angle area**.

■ 9.3 Relationship between measurement error of core loss Pc and phase angel θ (2)

- The following describes the relationship between the measurement error of the core loss Pc and the phase angle θ when a primary exciting current i_1 or a secondary induced voltage V_2 is the **distorted wave**; not a single sine wave.

  If a primary exciting current i_1 or a secondary induced voltage V_2 is the distorted wave; not a single sine wave, the measurement accuracy of **the core loss PC becomes worse** than described in Section 9.2. This cannot be also escaped from the pure mathematical principle.

  When both the primary exciting current i_1 and the secondary induced voltage V_2 are the distorted wave, the effective value of each frequency ingredient is i_n or V_n, and the phase difference between these ingredients is θ_n, the core loss Pc is expressed by expression (9.3).

$$P_c = \sum_{n=1}^{\infty} i_n \cdot V_n \cdot \cos\theta_n \qquad (9.3)$$

  In this case, the core loss measurement error is the total of each frequency ingredient of the core loss measurement error shown in expression (9.2), which can be estimated easily by Section 9.2 and which becomes worse.

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SY-8218 / SY-8219

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