HORIBA

INSTRUCTION MANUAL

CONDUCTIVITY METER

ES-51

HORIBA, Ltd.

Preface

Thank you for purchasing the ES-51 conductivity meter.
This meter is designed with a compact body that can be held in one hand and features a water-resistant construction Note 1. It has a large-sized LCD display, which enables to use the varied functions by simple operations, and especially will be convenient to use on-location.
Carefully read this manual before using the meter.

Note 1: The water-resistant construction of this meter conforms to IP-67 of IEC 529, entitled “Water resistant testing and protection against penetration by solid matter for electrical machinery and equipment.” To maintain the water-resistant construction of this meter, follow the instructions in this manual when using the meter.

IP-67 standards

・Dust does not get into internal parts.

・Water does not flow into internal parts when the meter is submerged 1 m below the surface of the water for 30 minutes, at a temperature differential between the water and the device of 5 ℃ or less.

HORIBA's Warranty and Responsibility

Your meter is covered by HORIBA's warranty for a period of one (1) year, under normal use. Although unlikely, if any trouble attributable to HORIBA should occur during this period, necessary exchange or repairs shall be conducted by HORIBA, free of charge. The warranty does not cover the following:

・Any trouble or damage attributable to actions or conditions specifically mentioned to be avoided in the operation manuals

・Any trouble or damage attributable to use of the meter in ways or for purposes other than those described in the operation manuals

・If any repairs renovations, disassembly, etc. are performed on this meter by any party other than HORIBA or a party authorized by HORIBA

・Any alteration to the external appearance of this meter attributable to scratches, dirt, etc. occurring through normal use

・Wear and tear to parts, the exchange of accessories, or the use of any parts not specified by HORIBA

HORIBA also shall not be liable for any damages resulting from any malfunctions of this product, any erasure of data, or any other uses of this product.

Unauthorized reprinting or copying of this operation manual

No unauthorized reprinting or copying of all or part of this operation manual is allowed. The utmost care has been used in the preparation of this operation manual. If, however, you have any questions or notice any errors, please contact the HORIBA customer service center printed on the back cover of this operation manual.

■ CE Marking

This product is in conformity with the following directives and standards:

Directives:The EMC Directives 89/336/EEC
The Electrical Product Safety Directive 73/23/EEC

Standards: EN61326: 1997+A1:1998
(EMISSION: Class B, IMMUNITY Category: Minimum Requirement)
EN61010-1: 2001

Installation Environment

This product is designed for the following environment.
- Pollution degree 2
- Measurement category **I**

WARNING:Do Not use the equipment for measurements within measurement categories
II , **III** and **IV** .

■ FCC Warning

This equipment has been tested and found to comply withthe limits for a Class A digital device, pursuant to part 15 of the FCC Rules.
These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment.
This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications.
Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be
required to correct the interference at his own expense.

■ Type and Definition of Signal Words

For the safety use, the meter is equipped with the Warning Labels to alert every operator and user to the possible risk and danger. Before using understanding each message.
The meaning of signal words are as follows:

(WARNING) This indicates an potentially hazardous situation which, if not avoided, will result in death or serious injury.

(CAUTION) This indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury. It may also be used to alert unsafe practices.

■ Safety Precautions

For the safety use, be sure to read the following precautions:

⚠ WARNING:

- Do not use any unspecified AC adapters.
  Heat or fire may occur to cause fire or accidents.
- Do not disassemble or modify the meter.
  Heat or fire may occur to cause fire or accidents.

⚠ CAUTION:

- Do not use the serial communication or AC adapter in the place that may possibly contact with moisture.
  It may cause fire, electric shock, or breakage.
- Part of the electrode is made of glass; handle with care not to break it.

● Indication

⚠ WARNING

This indicates an potentially hazardous situation which, if not avoided, will result in death or serious injury.

⚠ CAUTION

This indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury. It may also be used to alert unsafe practices.

— Note ———

This mark indicates the operation requires a special care and attention.

— Ref. ———

This mark indicates to which the reader should go for reference.

— **HINT!** ———

This mark indicates reference information.

■ Cautionary Items

● Precautions

- ●Do not give physical shock to the meter like dropping or hitting.
- ●Do not immerse the meter into alcohol, organic solvent, strong acid, strong alkaline, and other similar solutions. The meter contains ABS resin, acrylic resin, and various rubber products in its body.
- ●Do not use a hair-dryer for drying the meter. When the meter is dropped into water or get wet, wipe it using soft cloth.
- ●Perform the key operation by the fingers, not by the hard object like metal stick or rod.
- ●Be careful not to let water into the meter when the electrode connector is empty or the AC adapter or serial communications cable has been connected. In those states, the meter is not water-proof.
- ●To disconnect the electrode cable or interface cable, pull them out with holding the connector part. Do not pull the cable part; it may cause a breakage.
- ●Do not remove the battery gasket or twist it.
- ●When opening the battery case, make sure that no foreign matter is attached to the battery gasket.
- ●Do not use any unspecified batteries ; it may cause a breakage.

● Location of use and storage

- ●The place which room temperature is at 0 ℃ to 45 ℃
- ●The place which relative humidity is under 80% and free from condensation

Do not use or store the meter at;

- ●The place of much dust
- ●The place with strong vibration
- ●The place with direct sunlight
- ●The place with corrosive gas generation
- ●The place near from an air-conditioner
- ●The place with direct wind

● Move and Transportation of the meter

To transport the meter, use the packaging box at the delivery. Transportation by any unspecified packing methods may cause a breakage.

● Disposal

Standard solution used for the calibration must be under neutralization before the disposal. As for the disposal of the meter, treat it as an industrial waste.

CONTENTS

1 Overview of the Meter

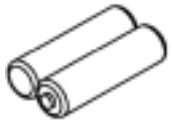
This chapter explains the part names, how to connect the electrodes, how to replace the batteries, and precautions when using the meter.

1.1 Package contents

The following items are shipped with each HORIBA conductivity meter package.

Meter (main unit) 1 unit

Dry-cell batteries 2 pcs.



Strap 1 pc

Soft case 1 pc

Operation manual 1 book

Note

To take measurements, you will need electrode(s).
Refer to “7.6 Spare and optional parts” page 104 when purchasing the electrode(s).

1.2 Functions

The ES-51 features the following functions.

● Measurement items

Items	Required electrode/ standard solution
Conductivity	Conductivity electrode, Conductivity standard solution
Salinity	
Resistivity	
Temperature	—

● Functions

An overview of the functions found on HORIBA the ES-51 is shown below.

Function	Explanation	Page No.
Data memory	Stores the data of measured values and temperature to the memory (max. 300 items)	page 27
Clock	Displays the time on the screen and recorded data.	page 27
Auto Power OFF	Automatically turns off power if no operation is made after 30 minutes.	page 44
RS-232C communication	Enables the communication with a computer using RS-232C.	page 49
Printer output	Prints the contents of the memory.	page 71
AC adapter connection	The meter can be AC-powered.	page 14

● Setting Items

Function	Explanation	Page No.
Temperature compensation	Toggles between Automatic Temperature Compensation (ATC) mode that measures the sample temperature using the temperature sensor built-in the electrode and Manual Temperature Compensation (MTC) mode that uses user-specified temperature.	page 34
Auto data memory	Stores data automatically at an interval of 2 sec. to 24 hours.	page 35
Sample ID	Registration of sample ID	page 37
COND unit	Toggles between S/m and S/cm.	page 38
COND temperature coefficient	Automatically or manually sets temperature coefficient for a sample.	page 38

Note

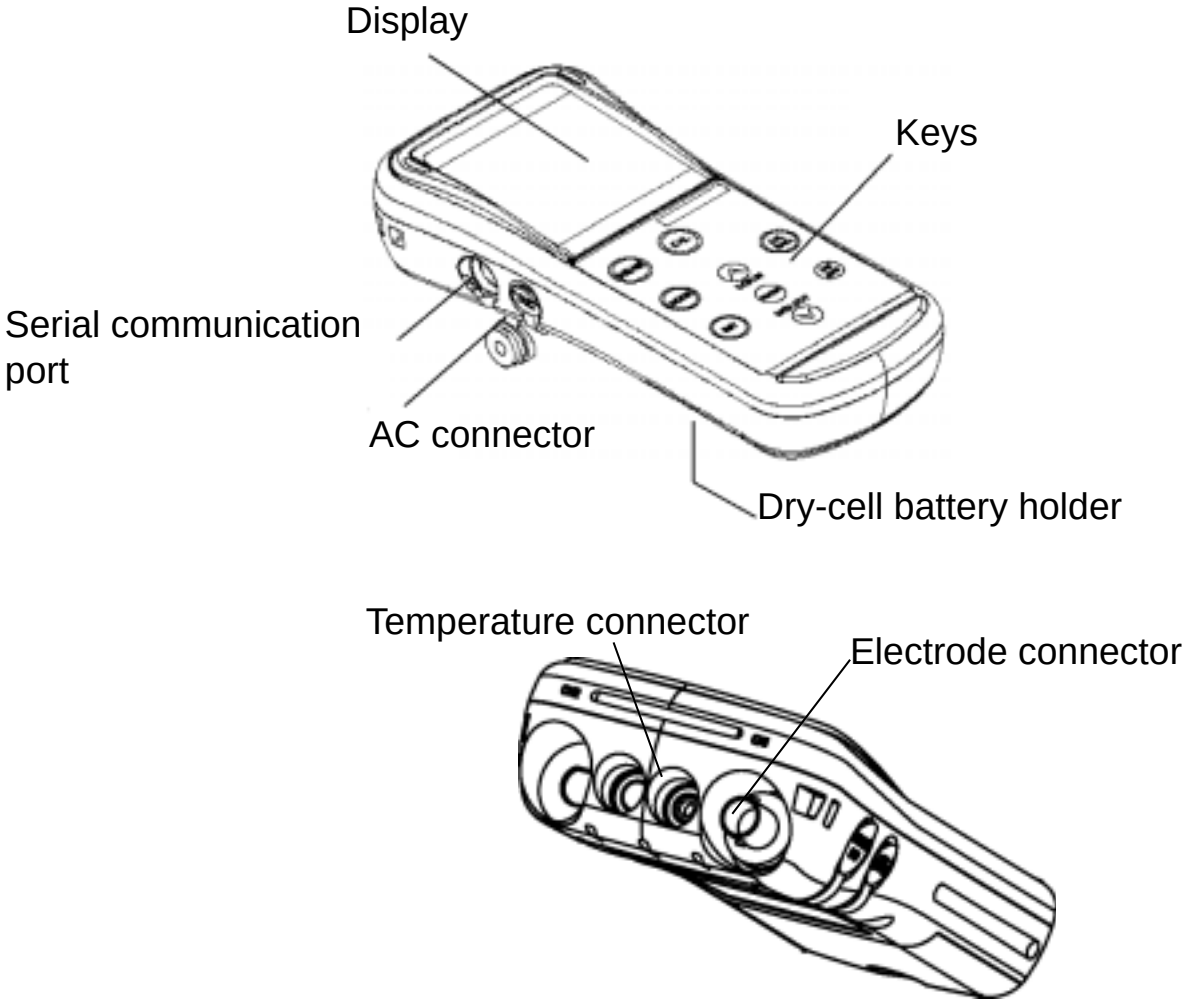
RS-232C communications and the printer cannot be used simultaneously.

● Functions in Maintenance mode

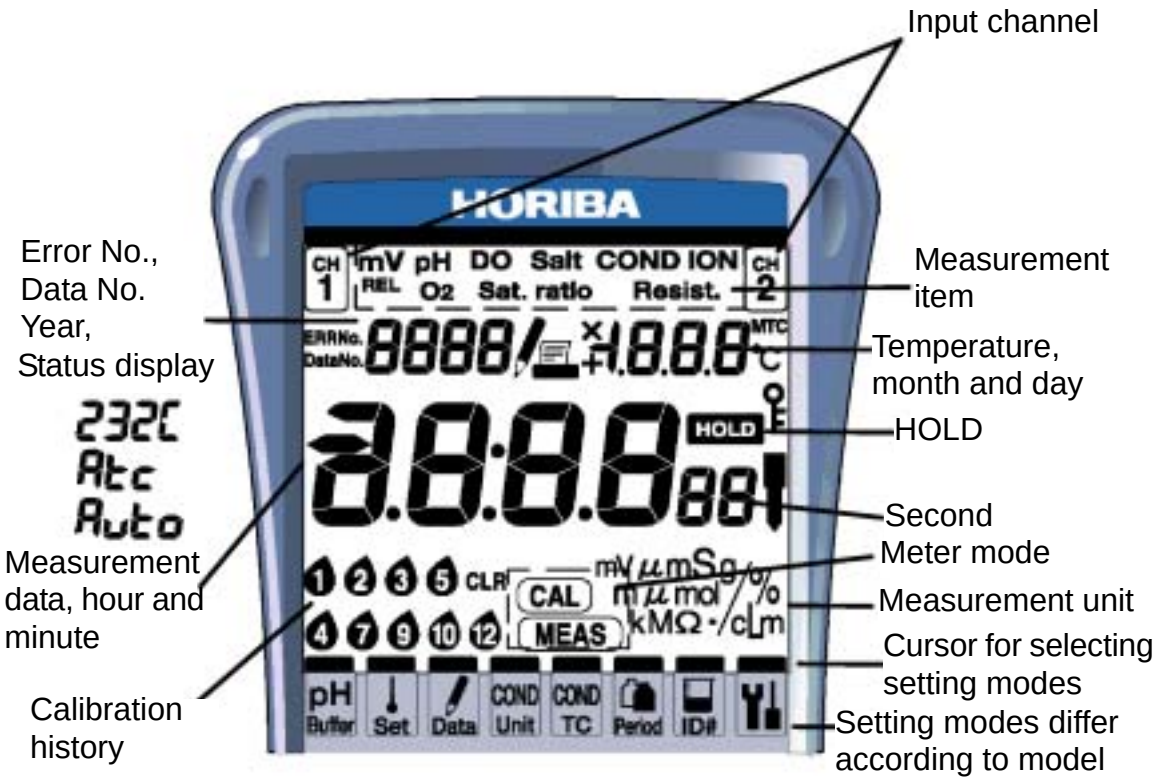
Function	Explanation	Page No.
LCD check	Enables check for whether or not all LCD segments are displayed.	page 41
Battery voltage check	Enables simple check of battery voltage.	page 42
Temperature zero adjustment	Carries out temperature calibration.	page 43
Auto Power OFF	Sets the function that automatically turns the power OFF if no keys are touched 30 minutes.	page 44
Remaining data memory	Displays the remaining memory.	page 45
Data memory clear	Deletes data in memory.	page 45
Initializing settings	Initializes all settings to the default values.	page 46
Printing test	Conducts a printing test.	page 47

1.3 Part names

The ES-51, conductivity meter has the following parts:



1.4 Explanation of display



Part name	Display	Contents
Input channel	CH 1	Input channel 1
	COND	Displayed when measuring conductivity
Error No.	ERRNo.	Displayed when an error is generated
Data No.	DataNo.	Displayed when the data number has been set.

Part name	Display	Contents
Status display – – –		Shows error number and data number.
		Displayed when AUTO data memory is being performed.
		Displayed when the serial communication is active.
		Displayed when temperature compensation function or automatic temperature compensation has been set.
		Displayed during data memory function (for 3 sec.). Displayed while data in memory is being called up and when manual data memory is being called up, or blinks when automatic data memory is being called up.
		Displayed when a printer is connected. (Sometimes displayed when a computer is connected depending on the computer.)
		Displayed during manual temperature compensation. Not displayed during automatic temperature compensation.
HOLD		Displayed while the data is held (HOLD status). Blinks during measurement or calibration.
Meter mode		Displayed when in Measurement mode.
		Displayed when in Calibration mode.

1.5 Operation keys

This section describes the functions of the keys.

	Name	Description
	MEAS key	Returns to the Measurement mode. Starts measurement.
	MODE key	Selects measurement item.
	SET key	Selects setting item.
	CELL key	Enters the Cell Constant Setting mode.
	UP key	Executes the data memory function. Increases numerical value.
	ENTER key	Establishes the setting.
	DOWN key	Calls up data memory. Decreases numerical value.
	ON/OFF key	Turns ON/OFF the power. This key takes effect only after pressed for one second to prevent accidental operation.

Note

The automatic power-off function is a default setting for this meter. The power is automatically turned OFF if no operation is performed after a period of approximately 30 minutes.

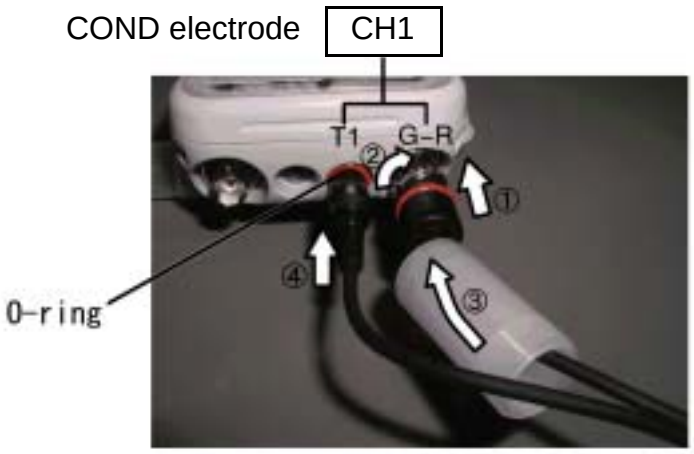
1.6 Connecting the electrodes

Connect the electrodes to the conductivity meter using the following procedures. Use special care to ensure that no water or dirt come in contact with the connector during connection procedures.

- Electrode connector: Conductivity electrode
- Temperature connector: Temperature electrode

● Electrode connector (G-R electrode)

1. Insert the electrode connector, making sure to align the connector grooves with the pins in the connector port on the main unit (see photo, ①). Do not push the electrode with undue force when the pins are not properly aligned.



Note

Do not perform this step with wet or uncleaned hands.

2. Push the electrode connector into the connector port while turning it clockwise, following the grooves (see photo, ① and ②).

3. Push the connector cover over the connector (see photo, ③), being careful to push it straight on without turning it.

Note

The meter will be waterproof only if this cover is placed properly over the connector.

● Temperature connector

1. Insert the temperature connector into the jack on the main unit until the O-ring on the electrode cannot be seen at all (see photo, ④).

Note

The meter will not be waterproof if the electrode is not inserted properly.

Note

When the temperature electrode is not connected (or is connected improperly), the automatic temperature compensation (ATC), will be 25°C.

1.7 Inserting/replacing the dry-cell batteries

The dry-cell batteries are not placed in the meter before shipping. To insert the batteries, follow the procedure below.
Note that if “ERR 2” appears on the display while using the meter, it indicates that the charge of the dry-cell batteries is running low. When this occurs, replace the batteries promptly.
Dry-cell battery type: AA alkaline

Note

• Insert the batteries, paying attention to the orientation of the battery poles (“ + ”and “ - “).

• Removing the batteries will erase the clock data. To save the clock data, remove and replace the batteries while the meter is connected to the AC adapter (sold separately).

• Replace the batteries only after turning the power OFF. Any saved data will not be lost.

• When opening and closing the battery cover, be careful that no water gets inside the meter.

• Check that the rubber packing is not twisted and no foreign matter is stuck to it. Otherwise the meter may no longer be waterproof.

Note

The life of the batteries included with the meter may be short because the batteries were used for the operation check before shipping.

To insert/replace the batteries

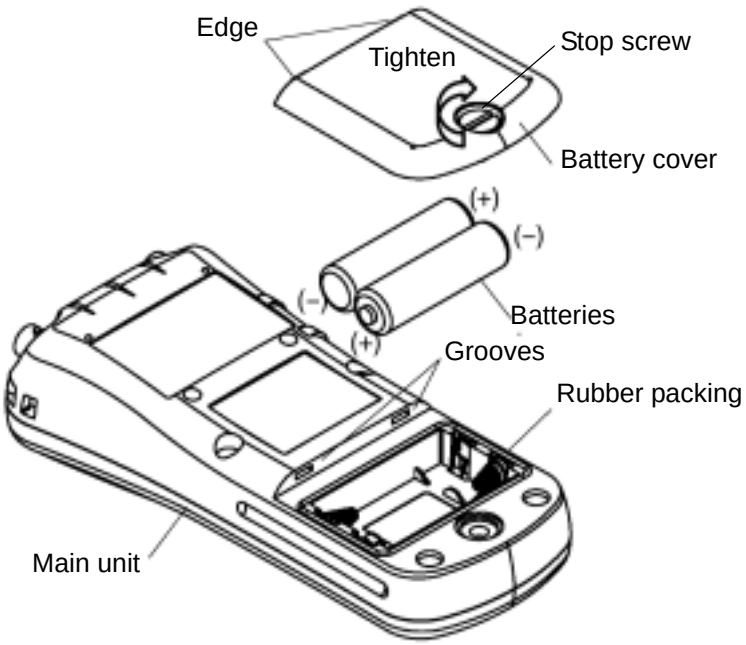
1. Loosen the screw of the battery cover by using a coin or screwdriver, etc. The cover is constructed so that the stop screw cannot be completely removed and lost.
2. Pull up the screw, and remove the battery cover by sliding it out.

3. If there are old batteries inside, remove them.

4. Place the new batteries in the meter, verifying the orientation of the poles (“+” and “-”).

5. Check that the rubber packing is not twisted and no foreign matter is stuck to it.

6. Insert the edge of the battery cover into the grooves on the meter, and then tighten the stop screw.



Note

Check that the rubber packing is twisted and no foreign matter is stuck to it. Otherwise the meter may no longer be waterproof.

Battery life

The table below shows the battery life of alkaline batteries during continuous use. The life of manganese batteries is about a half of the alkaline batteries.

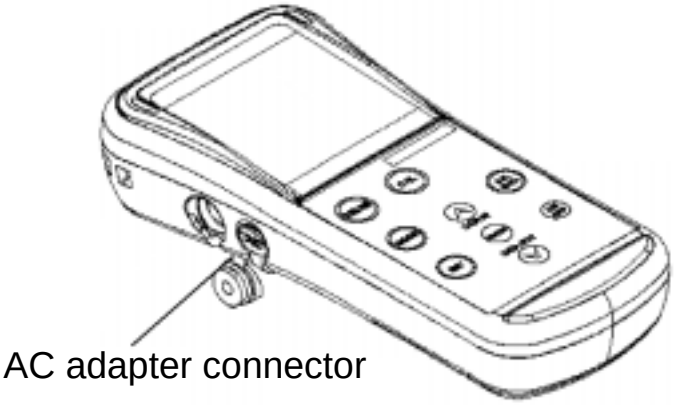
Battery life	approx. 100 hours

1.8 Connecting the AC adapter

When using the meter with an AC power supply, use the designated AC adapter (option).

AC adapter specifications

Supply voltage range	100 - 200 V AC
Frequency range	50/60 Hz
Current rating	Max 370 mA
Class2 Power supply	
Equipment protected by double insulation	
Indoor use only	
Supply voltage fluctuations allowed up to ± 10%	



Note

When the AC adapter is connected, the meter is no longer waterproof.
Be careful not to let water get into the meter.

2 Taking Measurements

This chapter explains how to take basic measurements.

2.1 Turning the meter ON/OFF

Pressing the ON/OFF key turns the power on/off. The ON/OFF key functions when it is pressed continuously for about one second to protect against accidental operation.

2.2 Settings required before measurement

The built-in clock allows you to record the date of calibration and data memory storage. When using the meter for the first time, be sure to set this clock.

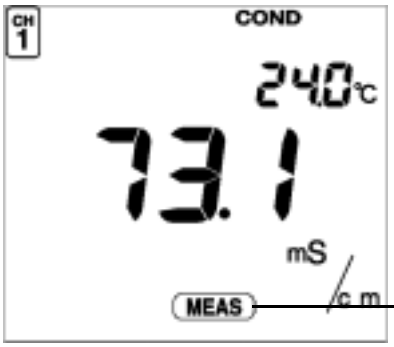
Ref.
“3.2 Displaying and setting the clock” page 30

2.3 Measurement modes

The ES-51, conductivity meter has an Instantaneous Value Measurement mode and an Auto Hold Measurement mode for all components of the solution being measured.

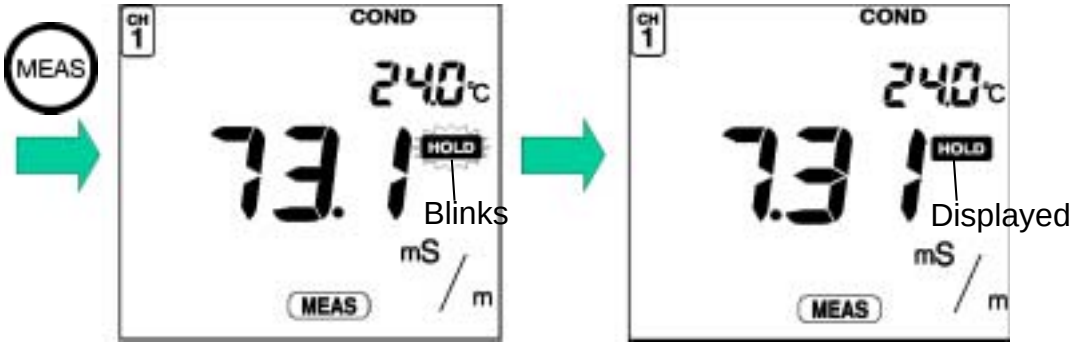
● Instantaneous Value Measurement mode

The ES-51, conductivity meter performs instantaneous value measurement as the default measurement mode when the power is first turned ON and when the auto hold measurement is cancelled or cleared.
For this reason, the screen displayed when the meter is in the Instantaneous Value Measurement mode is called the "initial screen" in this manual.



● Auto Hold Measurement mode

Auto Hold Measurement mode maintains the display of the value measured when the meter automatically judges that the measured value has stabilized. Press the MEAS key with the initial screeen displayed to make “HOLD”blink on the display. When the measured value becomes stable, “HOLD”will stop blinking and remain displayed, and the measured value will remain displayed. To clear the hold status or “stabilized”value (when “HOLD”is blinking), press the MEAS key.

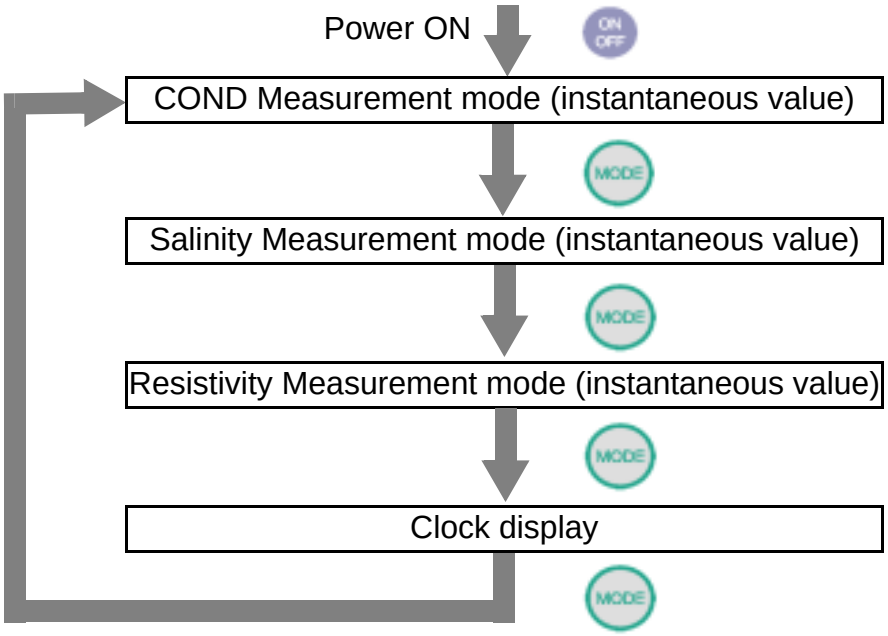


Criteria for judging stability

Conductivity measurement	:	Within ±3-digit variance after 10 seconds
Temperature measurement	:	Within ±2ºC variance after 10 seconds

2.4 Selecting the measurement modes

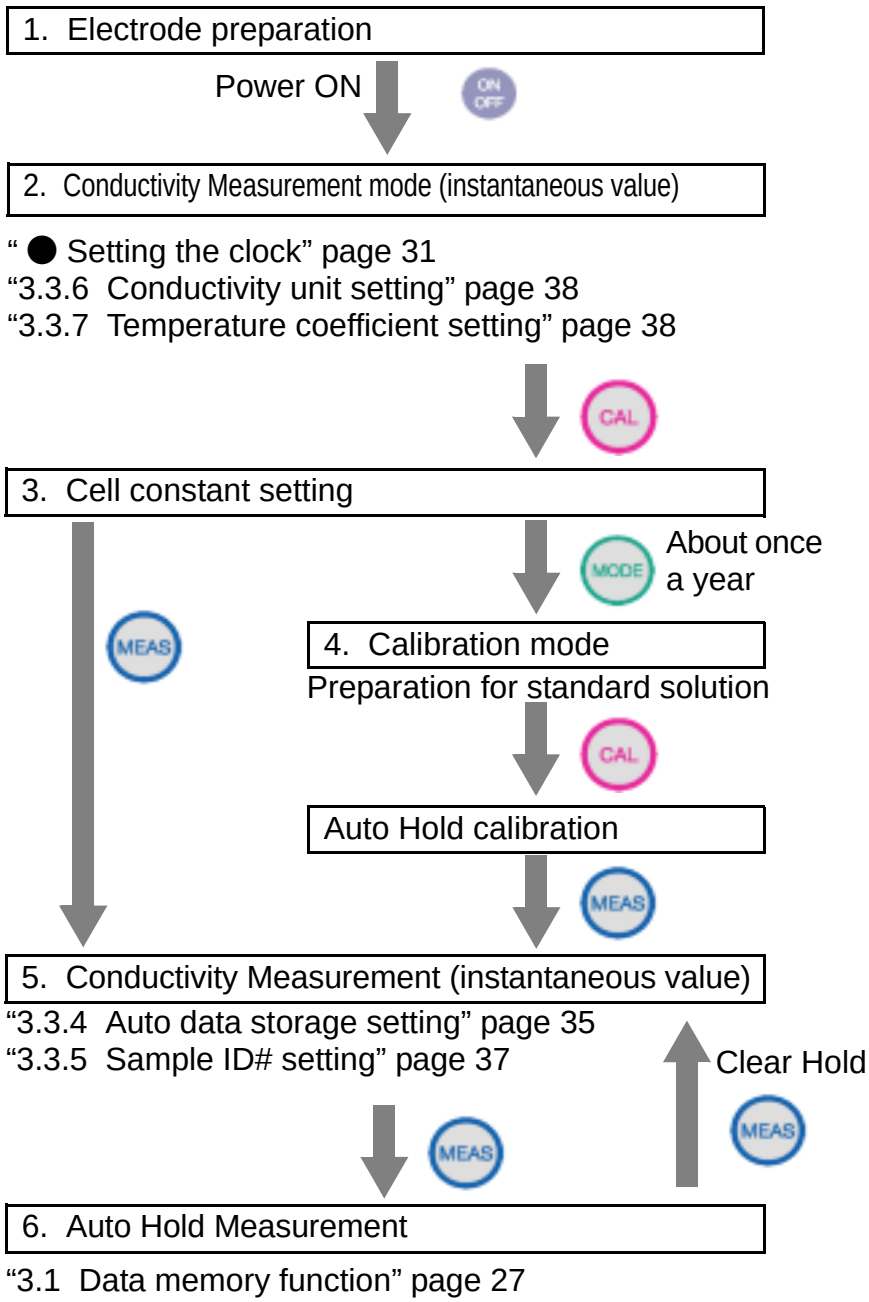
Pressing the MODE key changes the measurement mode. The last measurement mode item is the clock display. Pressing the MODE key once more returns the display to the first measurement mode.



2.5 Conductivity measurement

The following shows the operational flow for conductivity measurement.

● Measuring conductivity: basic operational flow



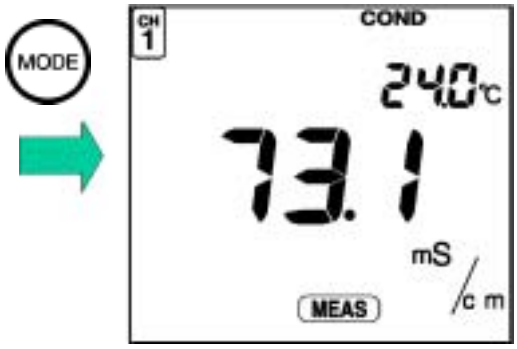
● Electrode preparation

Refer to the electrode instruction manual and make sure you have the correct electrode.

● Entering the Conductivity Measurement mode

1. Remove the electrode protective cap from the electrode.
2. Immerse the electrode in pure (de-ionized) water.
3. Select the Conductivity Measurement mode when the pH Instantaneous Value Measurement screen is displayed by pressing the MODE key.

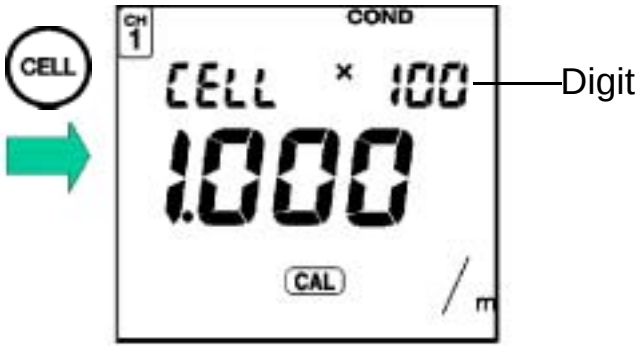
   The Conductivity Instantaneous Value Measurement screen will appear.



● CELL SET mode (Setting cell constant)

Set the cell constant the first time an electrode is connected to the main unit of the meter.

1. To enter the CELL SET mode, press the CELL key while in the Measurement mode.



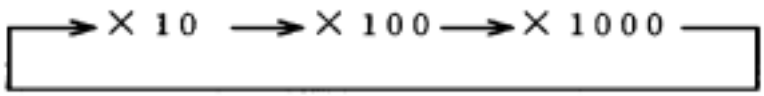
2. Change the digit number using the ENTER key.

3. Press the ▲ and ▼ keys to set the cell constant written on the electrode label.

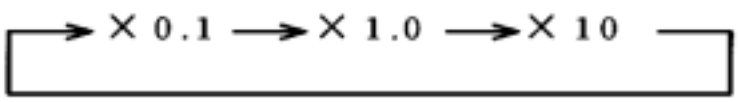
Setting range: 0.700 – 1.300

To change the coefficient, use the following procedure.

When the SI unit system (m^{-1}) is set:



When the former unit system (cm^{-1}) is set:



Note

Temperature coefficient

The default value of the temperature coefficient is set at 2.00%/ºC.

To change this setting, refer to “3.3.7 Temperature coefficient setting” page 38.

Unit Setting

The default value of unit is S/m (SI unit system).

To change this setting to the former unit system S/cm, refer to “3.3.6 Conductivity unit setting” page 38.

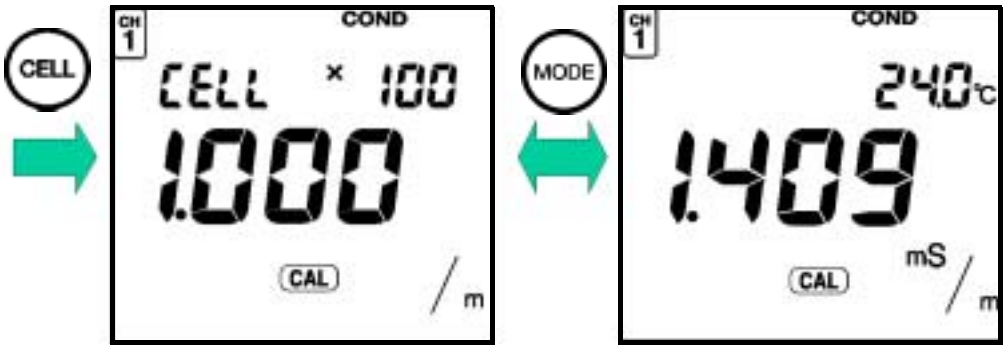
● Calibrating the cell constant

The cell constant of the electrode changes as the electrode is used. Calibrate the cell constant once a year or so.
Calibrating the cell constant will update it to match the condition of the current electrode.

Note

The cell constant is calibrated with a standard solution of potassium chloride.
To prepare a standard solution of potassium chloride, refer to “ ● Preparing potassium chloride standard solution” page 92.

1. Immerse the electrode in the standard solution of potassium chloride.
2. Enter the Calibration mode by pressing the MODE key in the CELL SET mode.



3. Enter the value of the standard solution used for calibration in the Calibration mode using the ▲ and ▼ keys.

Ref.

“ ● Conductivity and temperature coefficients for various solutions” page 97

Note

When the temperature conversion has been set to ON when setting the temperature coefficient, calibration is performed with the converted temperature.

4. Start the calibration by pressing the CELL key.

   HOLD is displayed and the calibration is completed.

   To redo the calibration, press the CAL key once more.

5. Press the MEAS key to enter the Measurement mode.

Note

If any calibration error occurs, take it as a indication that the electrode has gone bad. Replace the old electrode with a new one.

● Measuring conductivity

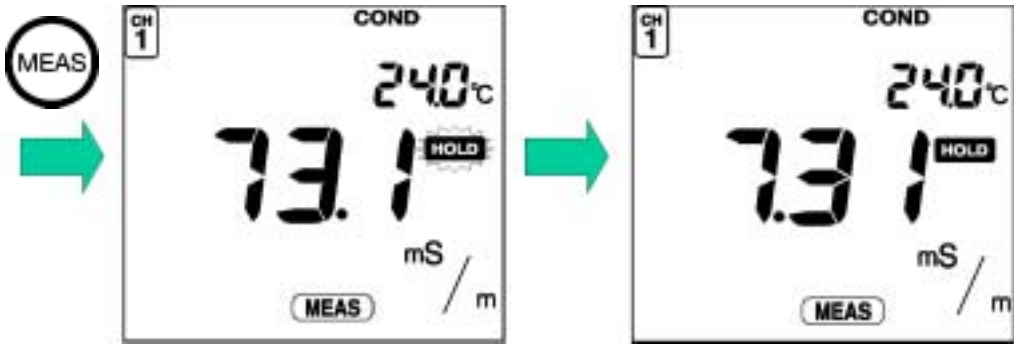
1. Immerse the electrode in the sample.

Note

Conductivity is greatly affected by temperature.
To measure with increased accuracy, use a temperature bath to keep the solutions at a constant temperature.

2. Press the MEAS key with the initial screeen displayed.

The measured value will be displayed, and "HOLD" will blink until the reading stabilizes. When the measured value stabilizes, "HOLD" will stop blinking and the measured value will remain displayed, and measurement will be completed.



Ref.

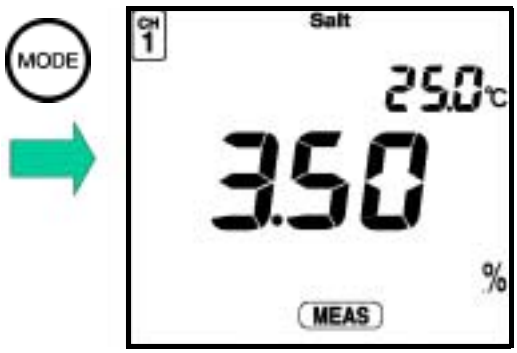
Refer to the " Criteria for judging stability" page 17 for the criteria for judging the stability of a readout.

Note

When the meter is in the Instantaneous Value Measurement mode or the measurement value is on HOLD in the Auto Hold Measurement mode, you can store the measurement data by pressing the ▲ key. "3.1 Data memory function" page 27.

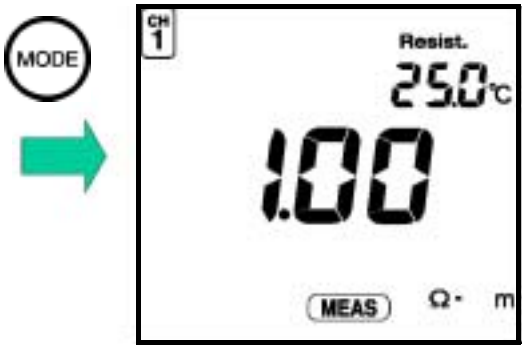
● Salinity measurement

Salinity can be measured using the conductivity electrode.
Enter the Salinity Measurement mode by pressing the MODE key in the Conductivity Measurement mode.



● Resistivity measurement

Resistivity can be measured using the conductivity electrode.
Enter the Resistivity Measurement mode by pressing the MODE key in the Conductivity Measurement mode.



3 Functions

This chapter describes the various functions of the conductivity meter.

3.1 Data memory function

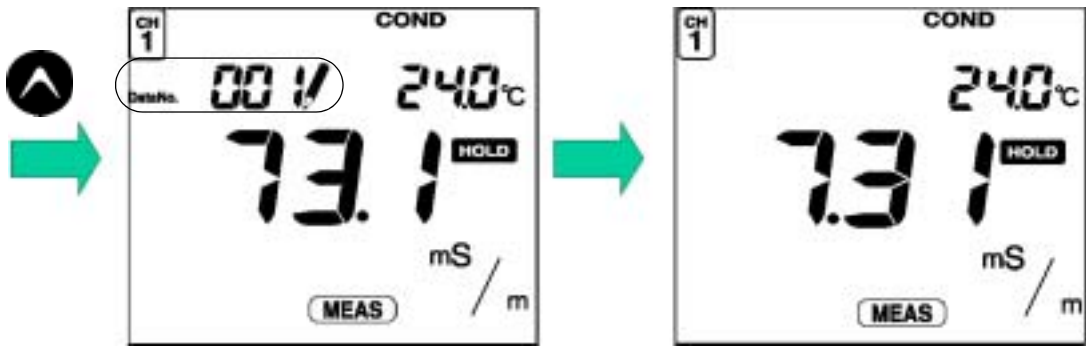
The measured data can be stored automatically or manually.

● Auto data memory

You can automatically store the data at certain intervals using this function. For the setting procedure, refer to “3.3.4 Auto data storage setting” page 35

● Data memory

In all measurement modes, you can store data when the instantaneous value is measured or the measured value is held (HOLD status) during the Auto HOLD measurement by pressing the ▲ key.
The measurement reading is stored along with the temperature, data, HOLD value/instantaneous value, ATC/MTC and sample ID at the time the measurement was taken.
After the data number is displayed, the screen returns to the initial screeen. Up to 300 items of data can be stored in the memory. If the number of data items exceeds the maximum limit, ERR 10 is displayed and no more data can be stored.



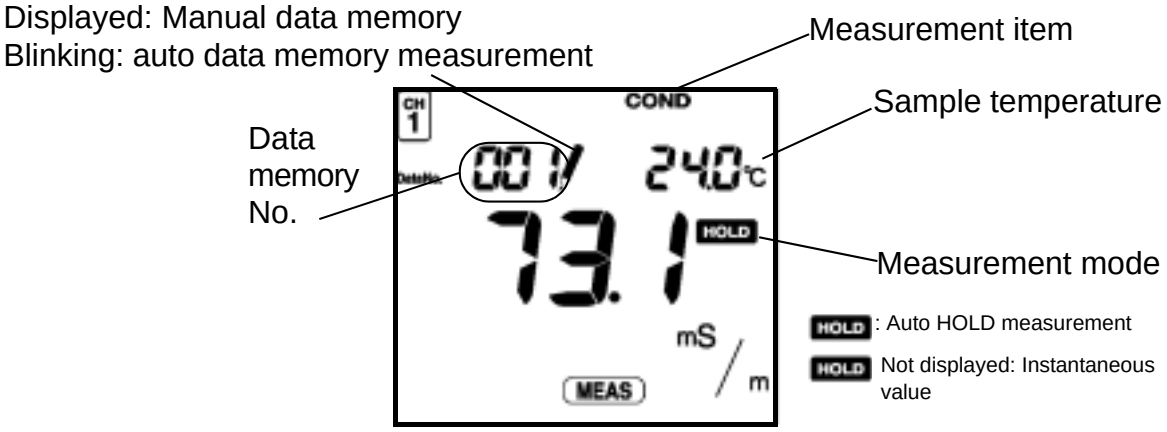
Note

Data cannot be stored unless the value has stabilized or in the CAL mode.

When the data is stored, an ID number for that specific measurement can be registered (see “3.3.5 Sample ID# setting” page 37).

● Calling up memory data

1. Press the ▼ key in the Measurement mode to load measurement data.



Select and load the desired memory data item using the ▲ and ▼ keys. The displayed number returns to 0 after 300, the maximum number.

2. Press the MODE key to display the data and time.

Select the desired data item using the ▲ and ▼ keys.

3. Press the MODE key to display the ID.

Select the desired data item using the ▲ and ▼ keys.

Note

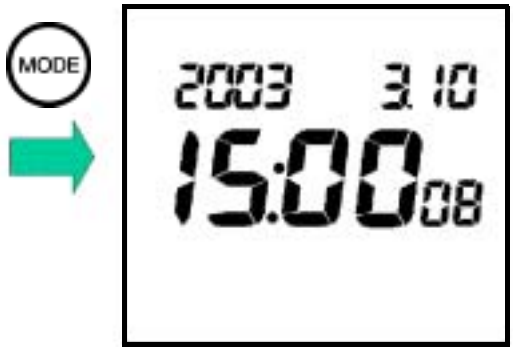
If an error occurs while a data number is being displayed, the error number will NOT be displayed. When using a printer (sold separately), press the ENTER key while in the DATA OUT mode to print the data.

3.2 Displaying and setting the clock

The clock needs to be when the meter is used for the first time or after replacing the batteries.

● Displaying the clock

Press the MODE key in the Measurement mode to display the clock.



● Setting the clock

1. Press the CELL key when the Clock Display screen is displayed to show the Setting screen for the clock.

2. Switch the display to year, month, day, hour, minute, and second using the ENTER key. You can set a numerical value using the ▲ and ▼ keys.

Note

Set the seconds to “00” sec. Pressing the ENTER key sets it to “00”.

3. After setting the clock, press the ENTER key to update the setting.

Pressing the CELL key at this time returns you to the Clock Display screen without changing the current setting.

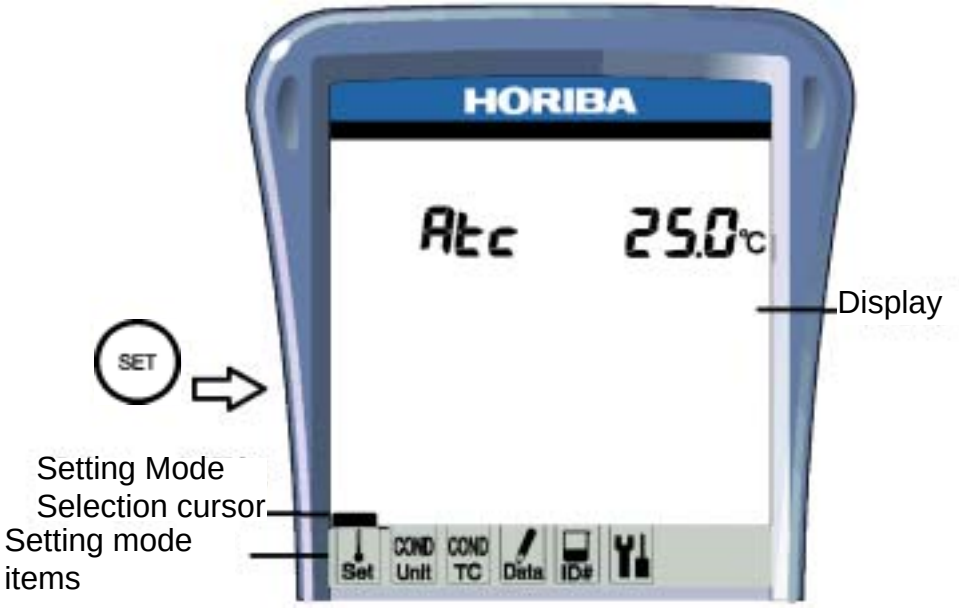
4. Press the MODE key to return to the Measurement mode.

3.3 Setting modes

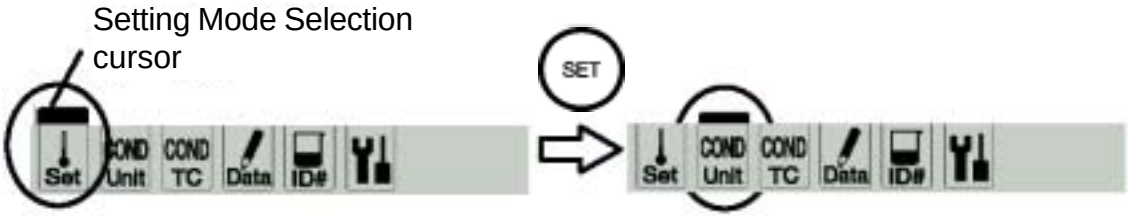
Selecting the Setting mode expands the uses of the meter.

3.3.1 Entering the Setting mode

1. Press the SET key in the Measurement mode. The Setting Mode Selection cursor appears at the left-bottom of the screen to indicate that the Setting mode is active.



2. Pressing the SET key moves the Setting Mode Selection cursor one by one to allow you to select the Setting mode of your choice.



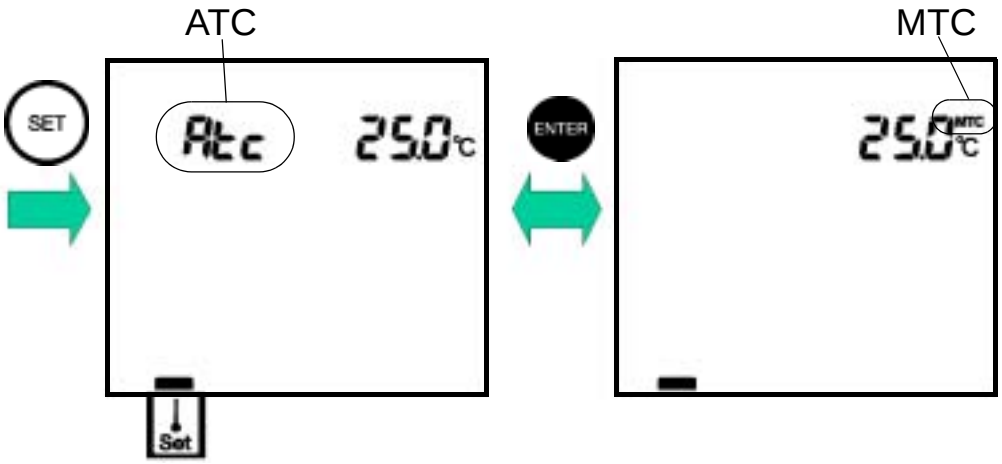
3. Press the MEAS key to return to the Measurement mode from the Setting mode.

3.3.2 Display and description

Display	Name	Description	Page No.
	Temperature Compensation Setting	Selects the Auto/Manual mode for temperature compensation.	page 34
	COND Unit Setting	Sets the unit for conductivity measurement.	page 38
	COND TC Setting	Sets the temperature coefficient for the sample to be measured in Conductivity Measurement mode.	page 38
	Data Memory Setting	Selects the Auto/Manual mode for data memory function	page 35
	ID#	Sets a number for a measured sample and stores its data.	page 37
	Maintenance	Sets various maintenance-related settings.	page 39

3.3.3 Temperature compensation setting

1. Press the SET key in the Measurement mode to enter the Temperature Compensation Setting mode.
2. Pressing the ENTER key toggles between MTC and ATC settings.



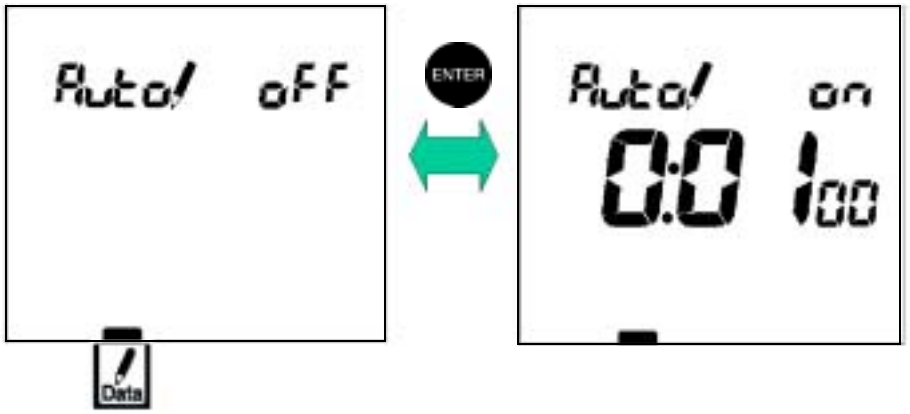
ATC
Automatic temperature compensation (when using a temperature sensor of the electrode)
ATC is displayed.
When a temperature sensor is connected, the current temperature is automatically displayed.
(When no temperature sensor is connected, the display shows 25◦C.)

MTC
Manual temperature compensation (when an electrode temperature sensor is not being used and the temperature of the solution is known before hand)
MTC is displayed.
Set the temperature using the ▲ and ▼ keys.
Setting range: 0.0 to 100.0◦C

3.3.4 Auto data storage setting

You can set the meter to automatically store data at certain intervals.

1. Cancel the Auto Power OFF function.
2. Press the SET key in the Measurement mode to enter the Data Storage Setting mode.
3. Pressing the ENTER key toggles auto data storage function ON and OFF.



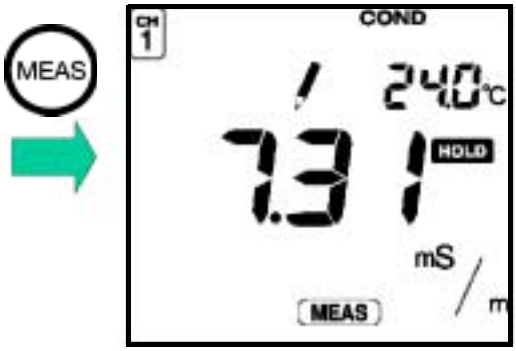
Memory interval setting

4. Press the MODE key to toggle between hour, minute, and second.
5. Specify a numerical value using the ▲ and ▼ keys.

   Setting range: 24 hours to 2 seconds

Carrying out auto data storage

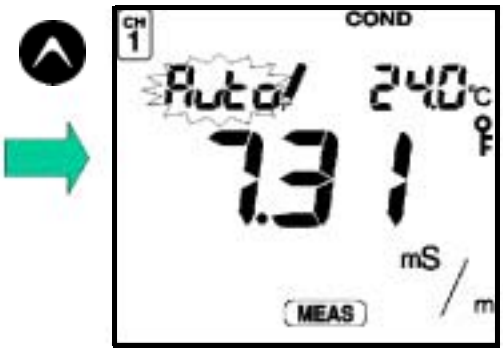
1. Press the MEAS key to return to the Measurement mode.



2. Press the ▲ key.

Automatic data storage will commence.

The first data is recorded when the preset time has reached the preset starting time.



Note

Do not turn the power ON/OFF during automatic data storage. The reliability of stored data may be compromised depending on when the ON/OFF key was pressed.

3. Press the CELL key.

Automatic data storage will end.

Note

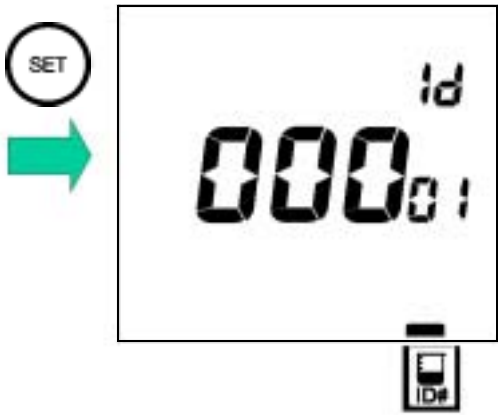
During automatic data storage, the MEAS, MODE, SET, ENTER, keys cannot be used. Data recording time will differ ± 1 seconds from the time set by the storage interval. If the number of stored data items exceeds 300, data storage will stop and the error message “ERR No. 10” will be displayed.

3.3.5 Sample ID# setting

Setting the sample ID# records its sample ID number as well as the measured data at time the data is stored.

1. Press the SET key in the Measurement mode to enter the ID# Setting mode.

2. Use the ENTER key to select the digit.

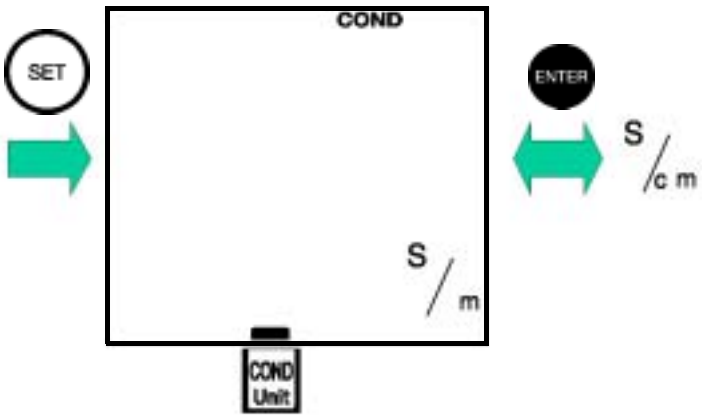


3. Specify a numerical value using the ▲ and ▼ keys.

Setting range: 00000 to 99999

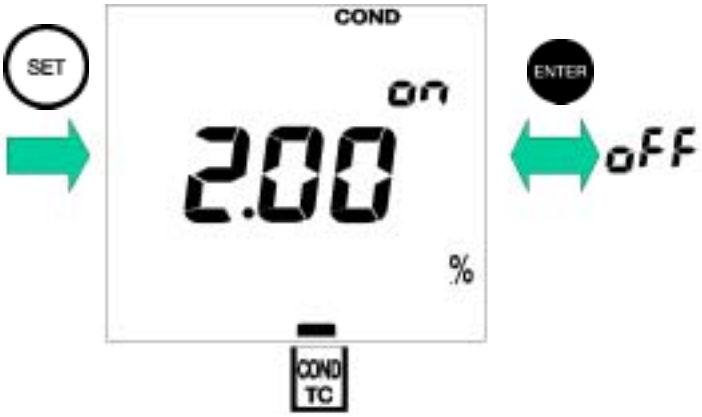
3.3.6 Conductivity unit setting

1. Press the SET key in the Measurement mode and select the COND Unit Setting mode.
2. Use the ENTER key to toggle between S/m and S/cm units.



3.3.7 Temperature coefficient setting

1. Press the SET key in the Measurement mode and select the COND TC Setting mode.
2. Pressing the ENTER key toggles the temperature conversion ON and OFF.

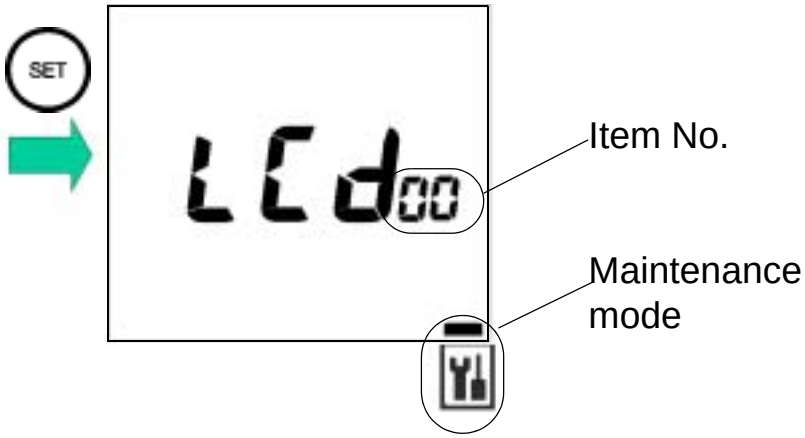


3. Specify a numerical value for the temperature coefficient using the ▲ and ▼ keys.

   Setting range: 0.00 to 10.00% per ℃

3.3.8 Maintenance mode

Press the SET key in the Measurement mode and select the Maintenance mode. The LCD CHECK screen (Item No. 00) will appear.



● Maintenance setting items

Use the MODE key to toggle between Maintenance mode items.

Item No.	Item	Description	Page No.
00	LCD check	Enables check to see if all LCD segments are displayed.	page 41
01	Battery voltage check	Enables simple battery voltage check.	page 42
02	Temperature zero adjustment	Carries out temperature calibration when the temperature sensor is immersed in a liquid of known temperature.	page 43
03	Automatic power-off setting	Turns Automatic Power-off function ON/OFF and sets time period after which the power will be turned off when no keys are touched.	page 44
05	Remaining data memoriy	Displays number of data items that can still be stored.	page 45
06	Data memory clear	Clears all data in the data memory.	page 45
07	Initialization of setting	Initializes all settings to default values.	page 46
08	Printer con-nection and printing test	Carries out a printing test.	page 47

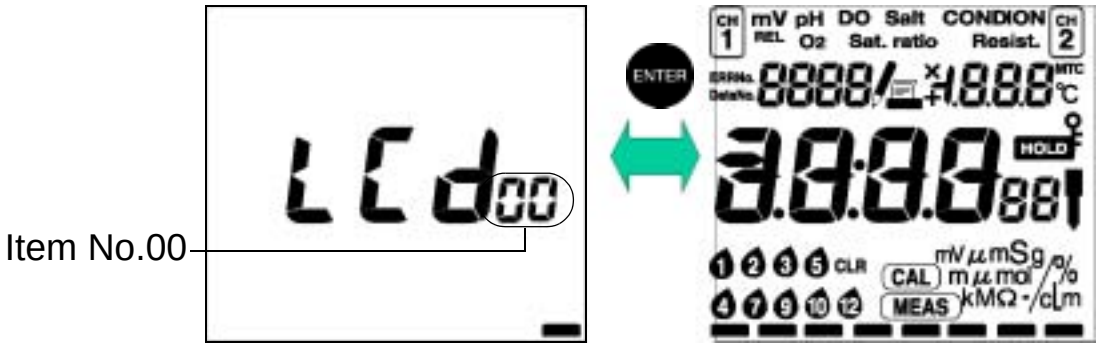
● LCD check [item No. 00]

Displays all segments of the LCD.

1. Press the MODE key in the Maintenance mode to show item No. 00.

2. Press the ENTER key.

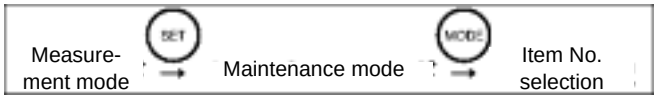
Compare the LCD screen with this diagram to confirm that all segments of the LCD are displayed.



3. Use the MODE key to proceed to the Battery voltage check (item No. 01).

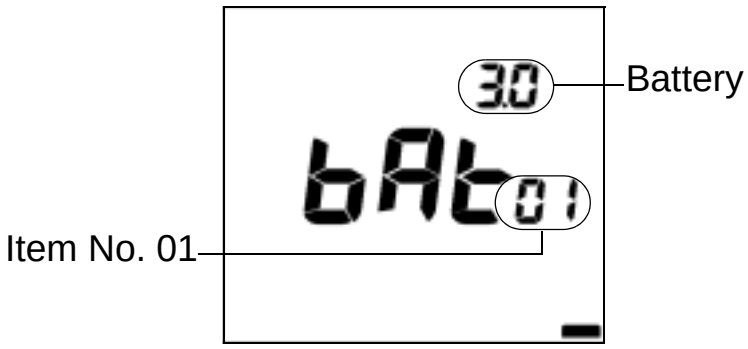
HINT!

Entering the Maintenance mode



● Battery voltage check [item No. 01]

The battery voltage (V) is displayed.



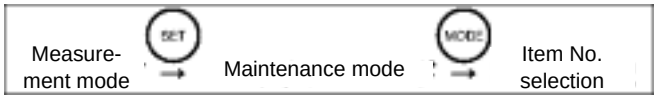
Note

The battery voltage alarm is set at approximately 2.2 V. The measured voltage for batteries depends on the current. The voltage shown in this mode will be a little lower than the actual voltage.

1. Use the MODE key to proceed to temperature zero adjustment (item No. 02).

HINT!

Entering the Maintenance mode

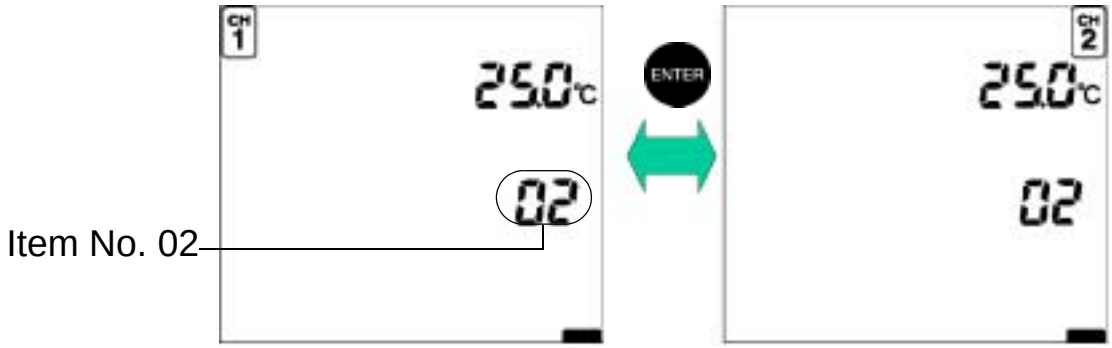


● Temperature zero adjustment [item No. 02]

This mode uses a known temperature to calibrate the temperature compensation value. This mode is used when calibrating the temperature of the thermometer.

1. Immerse the electrode in a liquid with a known temperature, and set the temperature using the ▲ and ▼ keys.

Setting range: 0.0 to 100.0 °C



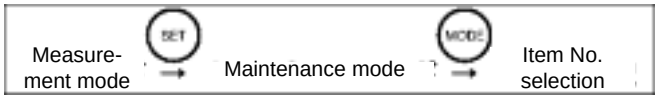
Note

The temperature sensor attached to the electrode maintains an accuracy of ±1°C, even without calibration. The above mode should be used when a greater precision than ±1°C is required.

2. Use the MODE key to proceed to Automatic power-off setting (item No. 03).

HINT!

Entering the Maintenance mode



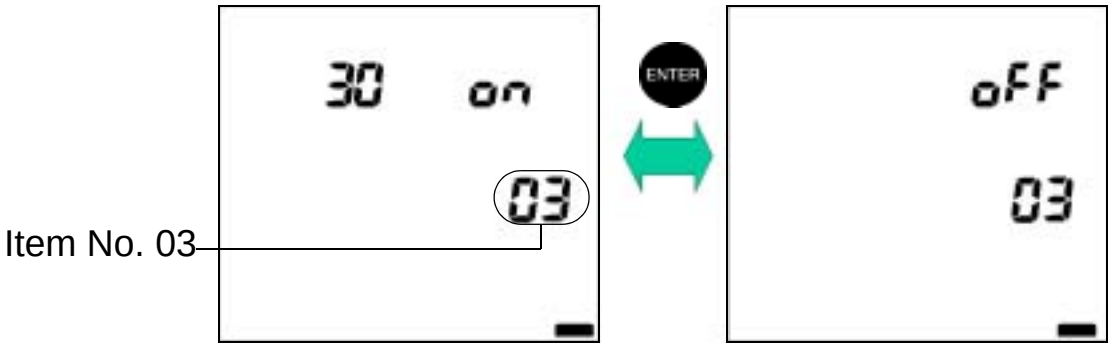
● Automatic power-off setting [item No. 03]

This turns the Automatic Power-off function ON/OFF and sets the time until the power is turned off.
When the Automatic Power-off function is set to ON, the power to the meter automatically turns off if the keys are not operated for the set amount of time.

1. Press the ENTER key to toggle between ON and OFF.

When set to ON, set the time for the power to be turned OFF using the ▲ and ▼ keys.

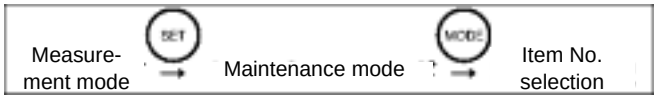
Setting range: 1 to 30 minutes



2. Press the MODE key to proceed to [Item No. 05] Remaining data memory.

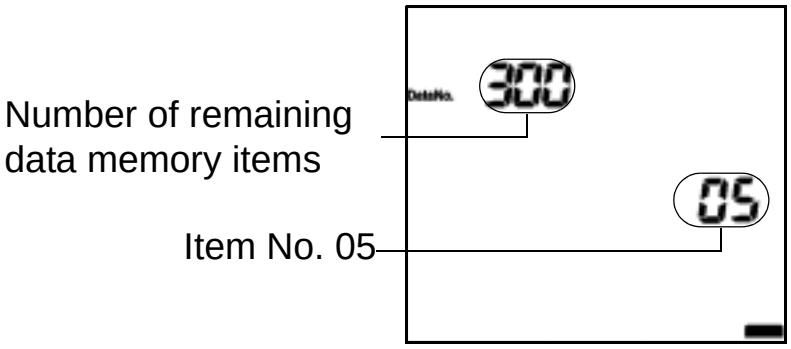
HINT!

Entering the Maintenance mode



● Remaining data memory [Item No. 05]

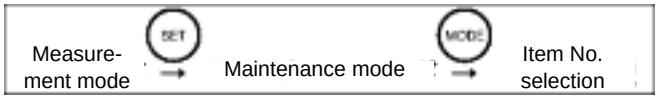
Displays the number of data items that can still be stored.



1. Press the MODE key to proceed to Data memory clear (item No. 06).

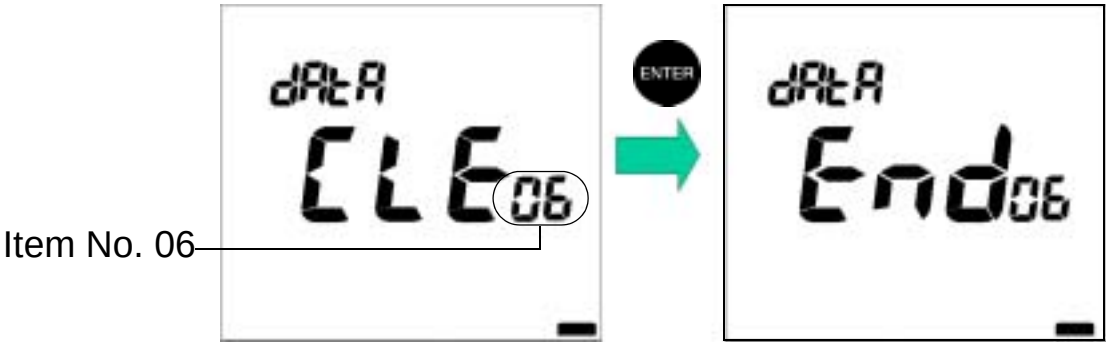
HINT!

Entering the Maintenance mode



● Data memory clear [Item No. 06]

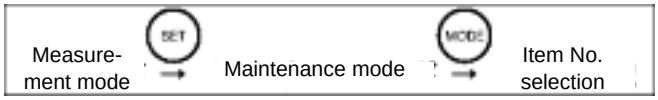
1. Pressing the ENTER key clears all the data stored in the memory.



2. Press the MODE key to proceed to Initialization of setting (item No. 07).

HINT!

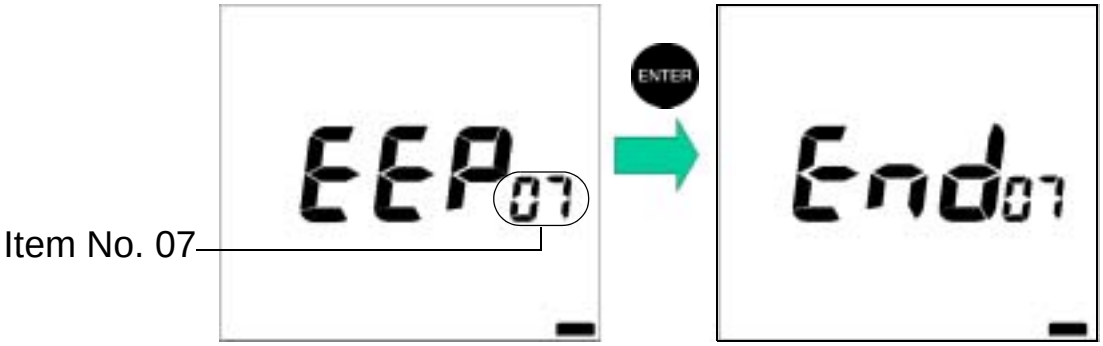
Entering the Maintenance mode



● Initialization of setting [item No. 07]

This mode returns all settings to the default settings. Use this mode to return the meter to the original settings when the meter was purchased.

1. Press the ENTER key to initialized the settings.



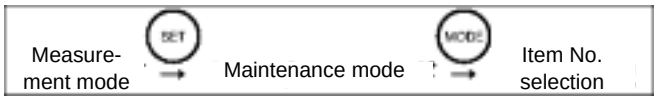
2. Use the MODE key to proceed to Printer connection and printing test (item No. 08).

Ref.

The setting values to be initialized are shown on page 101.

HINT!

Entering the Maintenance mode

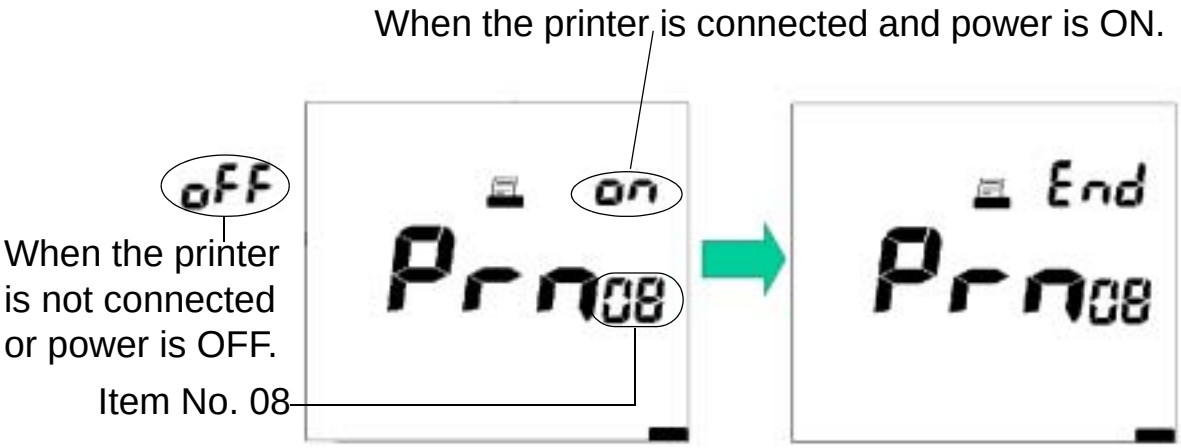


● Printer connection and printing test [item No. 08]

A printing test is conducted if a printer is connected.

1. Press the ENTER key to start the printing test.

When conditions are normal, “End” is displayed.
When conditions are not normal, “Err” is displayed.

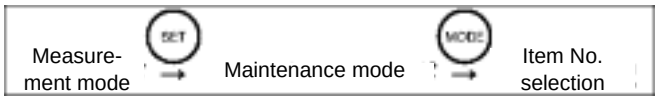


2. Press the MODE key to return to the first item in the maintenance modes, LCD check.

Test print format

HINT!

Entering the Maintenance mode



4 RS-232C communications

This chapter describes the use of RS-232C communications and its communication commands.

4.1 Cautions before use

Use caution regarding the following points, when using RS-232C communications.

- Use the following designated cable for connecting to the computer.
  Part name: PC cable for 50 Series
  Part number: 9096004800
- Make sure that the data transfer formats for the meter and computer match. The following data transfer format is used by the meter.
  Baud rate: 2400 bps
  Character length: 8 bits
  Parity: None
  Stop bits: 1

Note

If the data transfer formats differ, communications errors may occur or the on-line mode may not start up, and RS-232C communications cannot proceed normally. If the transfer format is changed, turn the power to both the meter and the computer OFF, and then ON again.

- When creating a program for RS-232C, put the meter in the ON-LINE mode by entering an on-line command at the beginning of the program. The control switches become invalid when the meter is in the ON-LINE mode, and the RS-232C Communications mode is enabled (“LOCK” is displayed.) The ON-LINE mode is cleared when the power is turned OFF.

- If data is requested but not received, create the program structure to have the data request repeated after a short waiting time. This will provide more reliable communications.
- If RS-232C communications is not used, cover the RS-232C port with a rubber cap.
- This system does not carry out control using DCD, CTS or DSR. Note this point when creating a program.

4.2 Command list

Use <CR><LF> as the terminator for serial communication commands.
All the commands (except the ON-LINE/OFF-LINE command) are valid only in the ON-LINE mode. (An error message is returned in the OFF-LINE mode.)
The meter returns a response to any operation made in the following format:

OK<CR><LF>

If the meter does not accept the operation, it returns an error message in the following format:

ER,n<CR><LF>

n=0: Communication error
1: When a non-existent command is input.
2: When a timing command is input to which the meter cannot respond.
3: When the numerical value in the command is out of the setting range.

● On-line operations commands

Command item	Command		Page No.
	Header	Command code	
On-line/off-line	C	OL	page 54
Halt potential hunting		BR	page 57
Conductivity Measurement mode designation		CO	page 54
Salinity measurement designation		SA	page 55
Resistivity measurement designation		OH	page 56
Start measurement		MS	page 56
Start conductivity cell constant calibration		CD	page 58
Data clear		DC	page 59
Data In designation		IN	page 59
Power Off		OF	page 59

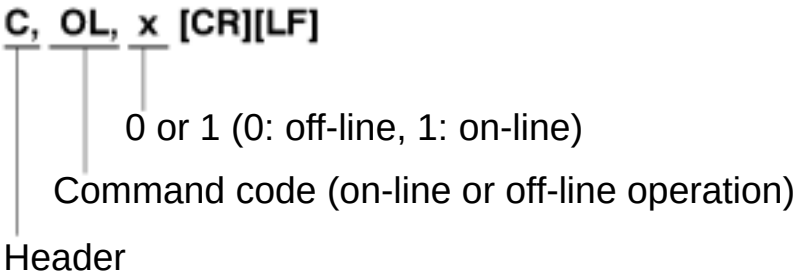
● Request data commands

Request for ...	Command		Page No.
	Header	Command code	
Clock data	R	OT	page 61
Measurement		MD	page 62
Number of stored data items		MC	page 64
Memory data		MS	page 65
Model inquiry	A	RS	page 65
Software version inquiry		AV	page 68

4.3 On-line operation commands

This section explains the commands that control the operation of the meter.

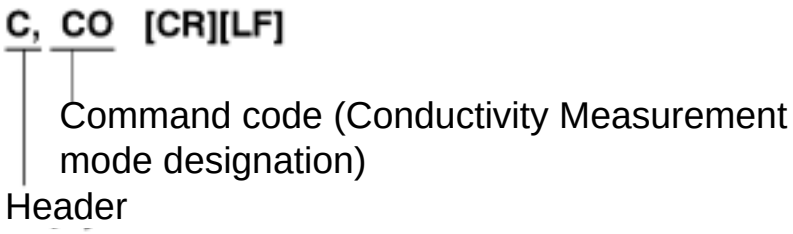
● ON-LINE/OFF-LINE command format



Note

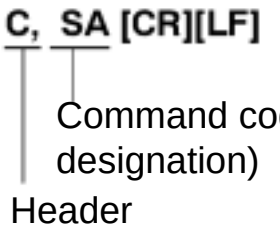
Switching between on-line and off-line. When the meter is switched from off-line to on-line, the status of the meter is the same as when a command has been received. “LOCK” is displayed.

● Conductivity Measurement mode designation command format



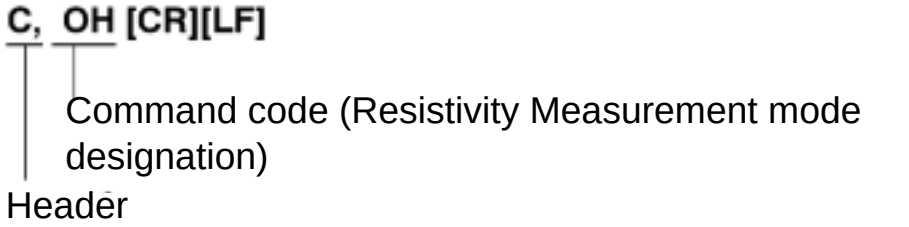
- This command is always valid when on-line.
- The meter changes the status to Conductivity Instantaneous Value display

● Salinity Measurement mode designation command format



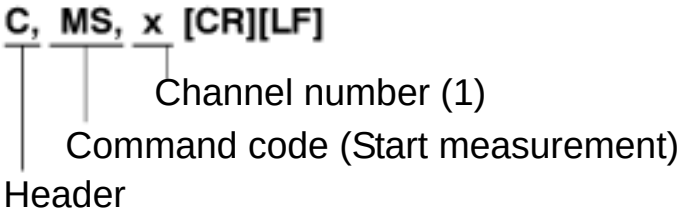
- This command is always valid when on-line.
- The meter enters the Salinity Instantaneous Value display.

● Resistivity Measurement mode designation command format



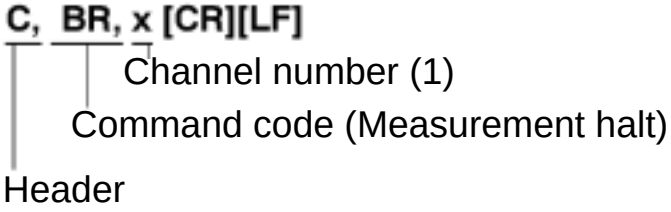
- This command is always valid when on-line.
- The meter enters the Resistivity Instantaneous Value display.

● Start measurement command format



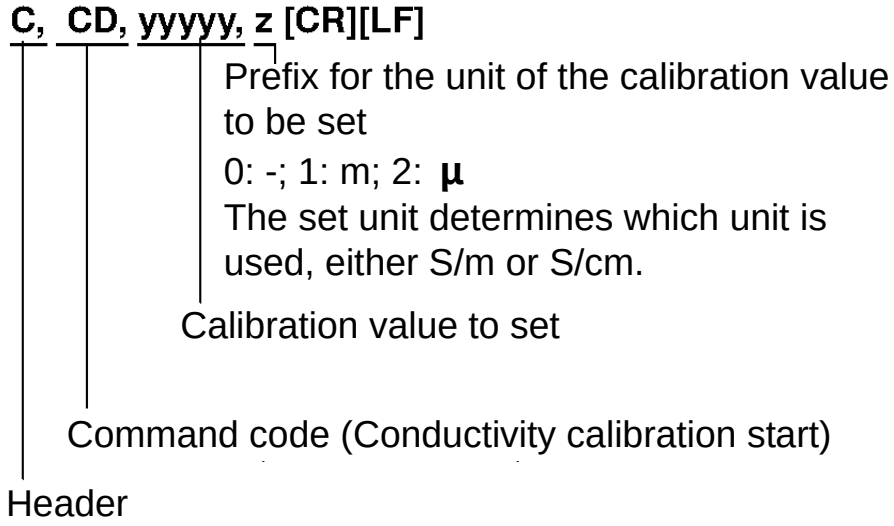
- When the meter status is Instantaneous Measurement, Auto Hold Measurement will start.
- If the command is issued during a measurement hold or during calibration, the meter will return to the initial screeen status.

● Halt potential hunting command format



- This command is valid when on-line only during measurement on AUTO HOLD.
- Issuing this command halts measurement on AUTO HOLD.

● Start conductivity cell constant calibration command format

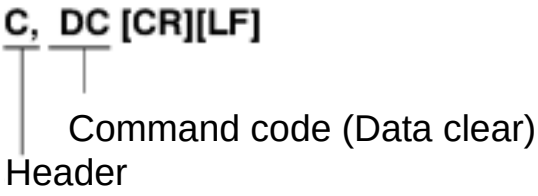


- This command is valid when on-line, when conductivity measurement or calibration are on HOLD.
- This command starts the calibration of the conductivity cell constant.

Setting ranges for calibration values

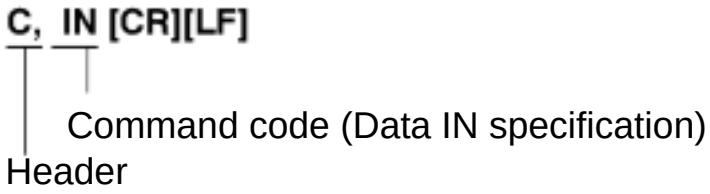
- When units are μS/m: 0.0 – 999.9 (only one place to the right of the decimal)
- When units are mS/m or S/m: 0.0000 – 199.9
- After calibration is completed, the cell constant/ coefficient will appear on the screen and be stored in the memory.

● Data clear command format



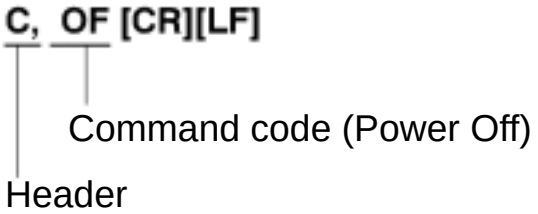
•This command clears the data stored in the memory.

● Data IN specification command format



•Valid only when manual data memory is set.

● Power Off command format



4.4 Data request commands and responses

This section explains the commands that request meter data.

● Format of responses from meter

When no operation can be received

ER, n [CR][LF]

n = 0: Communications error
1: Command code does not exist
2: Unacceptable timing entered
3: Data exceeds range

When operation has been received

A. When data is requested, the result of the request is sent out according to each format.
B. When an operation command has been issued, “OK” is sent back.

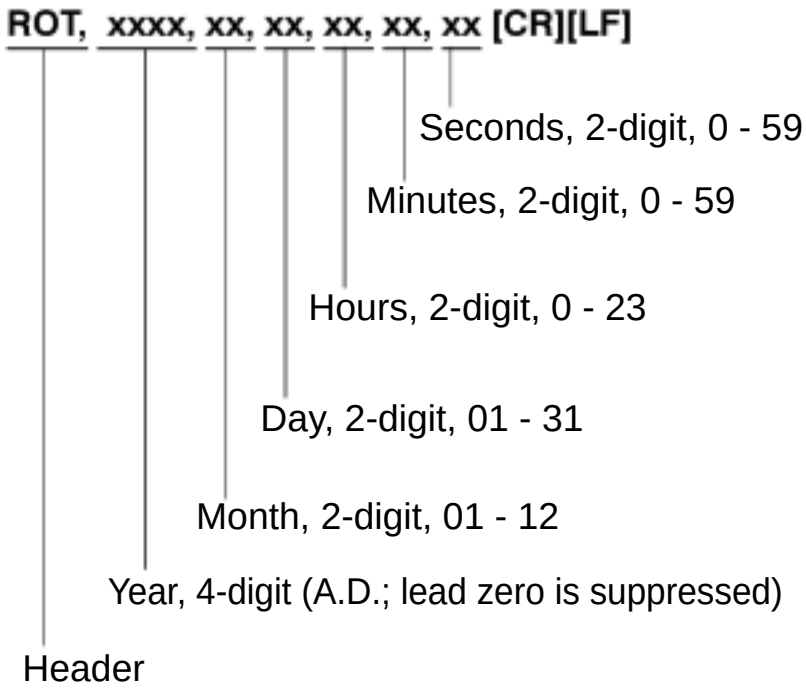
Format

OK [CR][LF]

● Clock data request command and response

Request command format

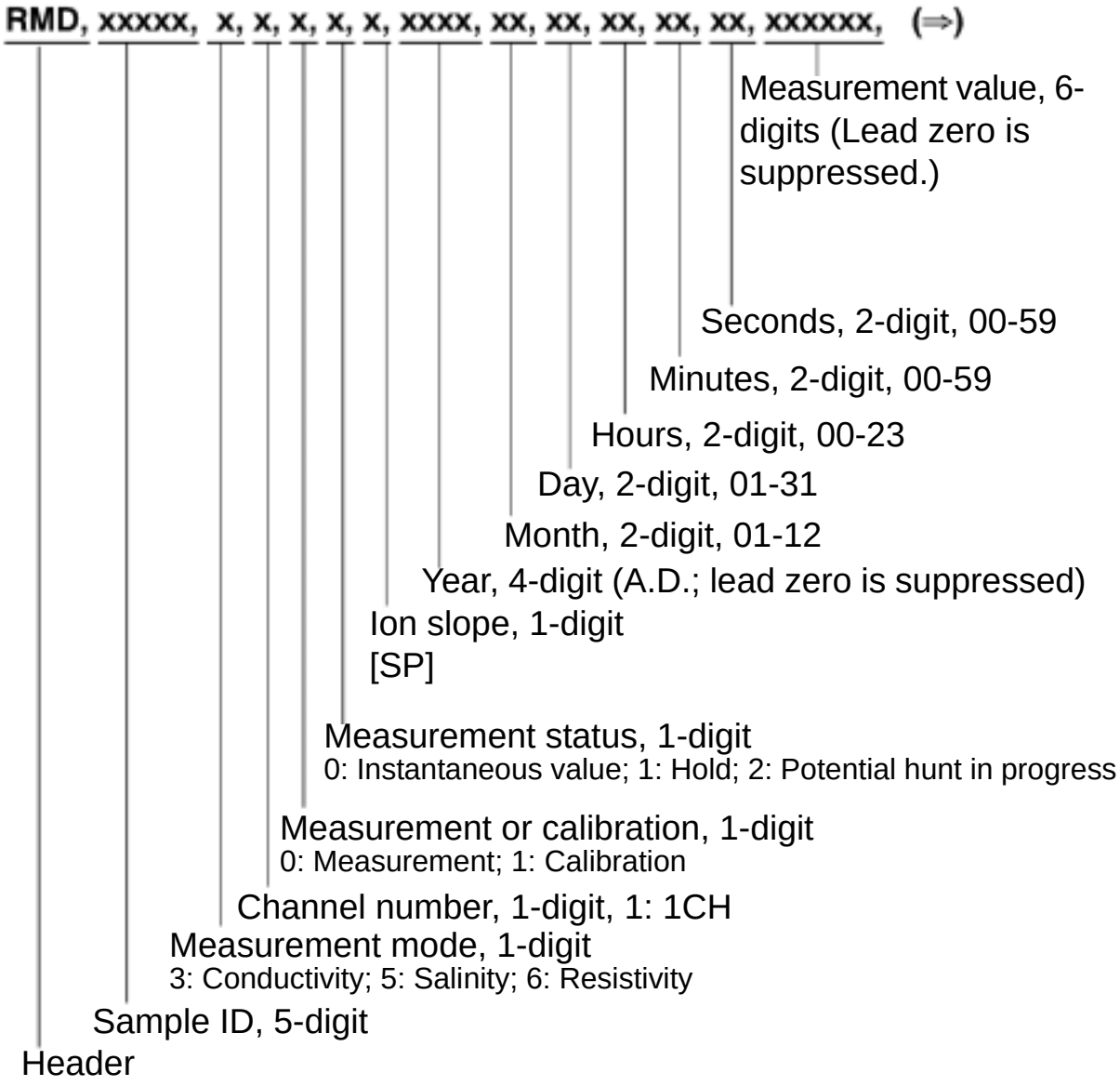
Meter response format

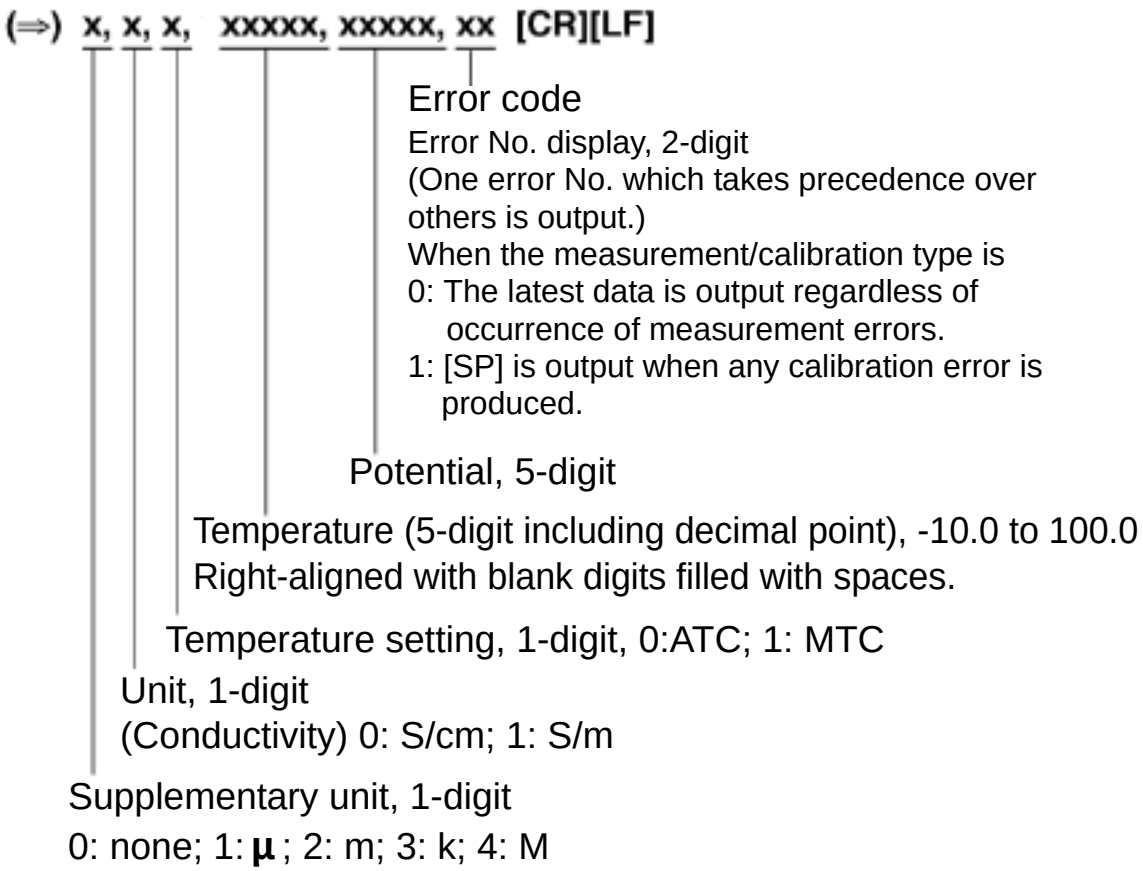


● Measurement request command and response

Request command format

Meter response format

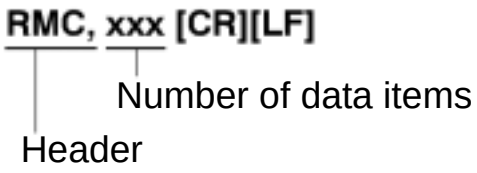



(⇒) x, x, x, xxxxx, xxxxx, xx [CR][LF]
Error code
Error No. display, 2-digit
(One error No. which takes precedence over others is output.)
When the measurement/calibration type is
0: The latest data is output regardless of occurrence of measurement errors.
1: [SP] is output when any calibration error is produced.
Potential, 5-digit
Temperature (5-digit including decimal point), -10.0 to 100.0
Right-aligned with blank digits filled with spaces.
Temperature setting, 1-digit, 0:ATC; 1: MTC
Unit, 1-digit
(Conductivity) 0: S/cm; 1: S/m
Supplementary unit, 1-digit
0: none; 1: μ; 2: m; 3: k; 4: M

● Request command for number of stored data items and its response

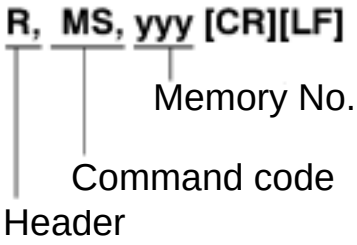
Request command format

Meter response format

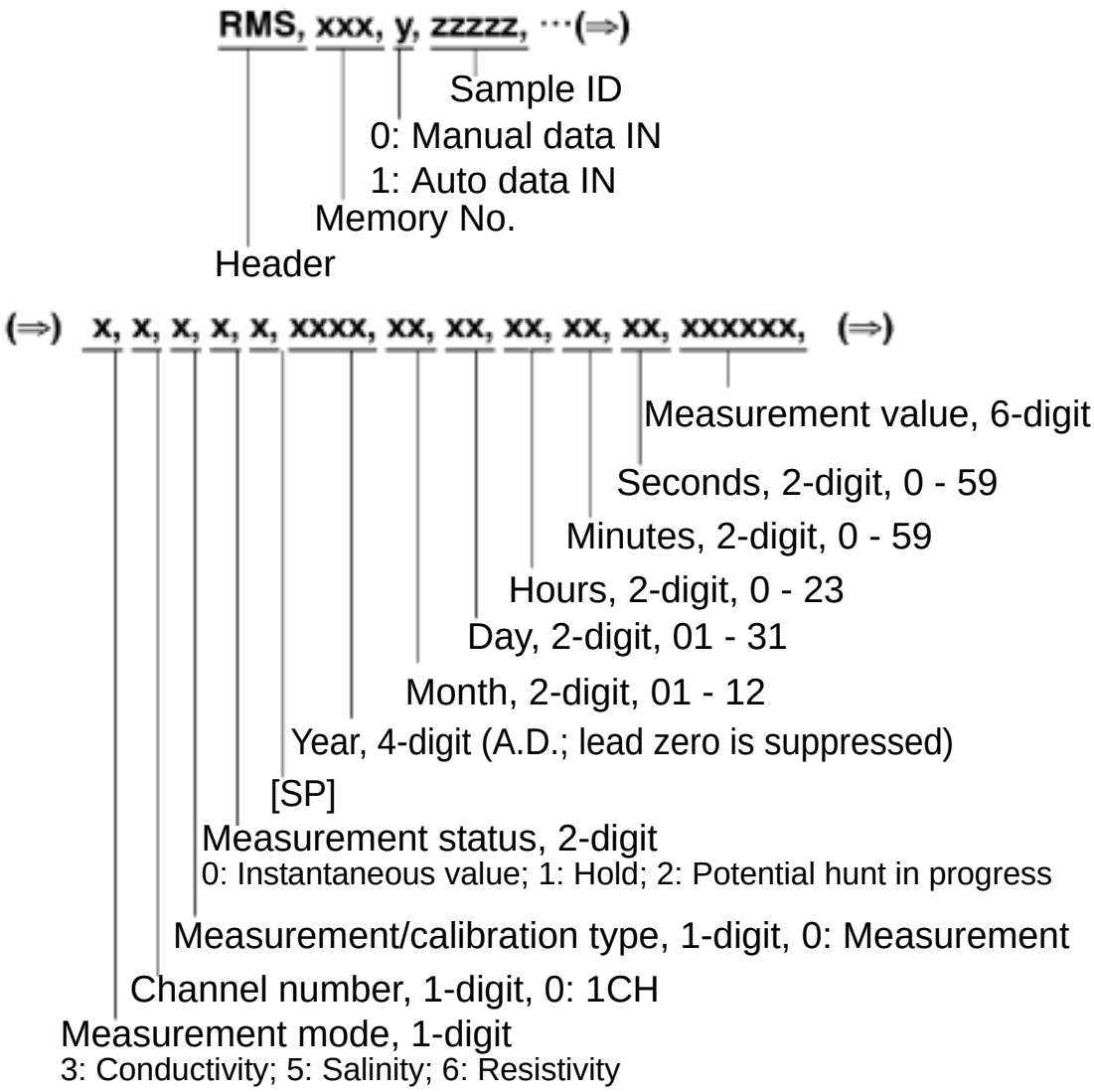


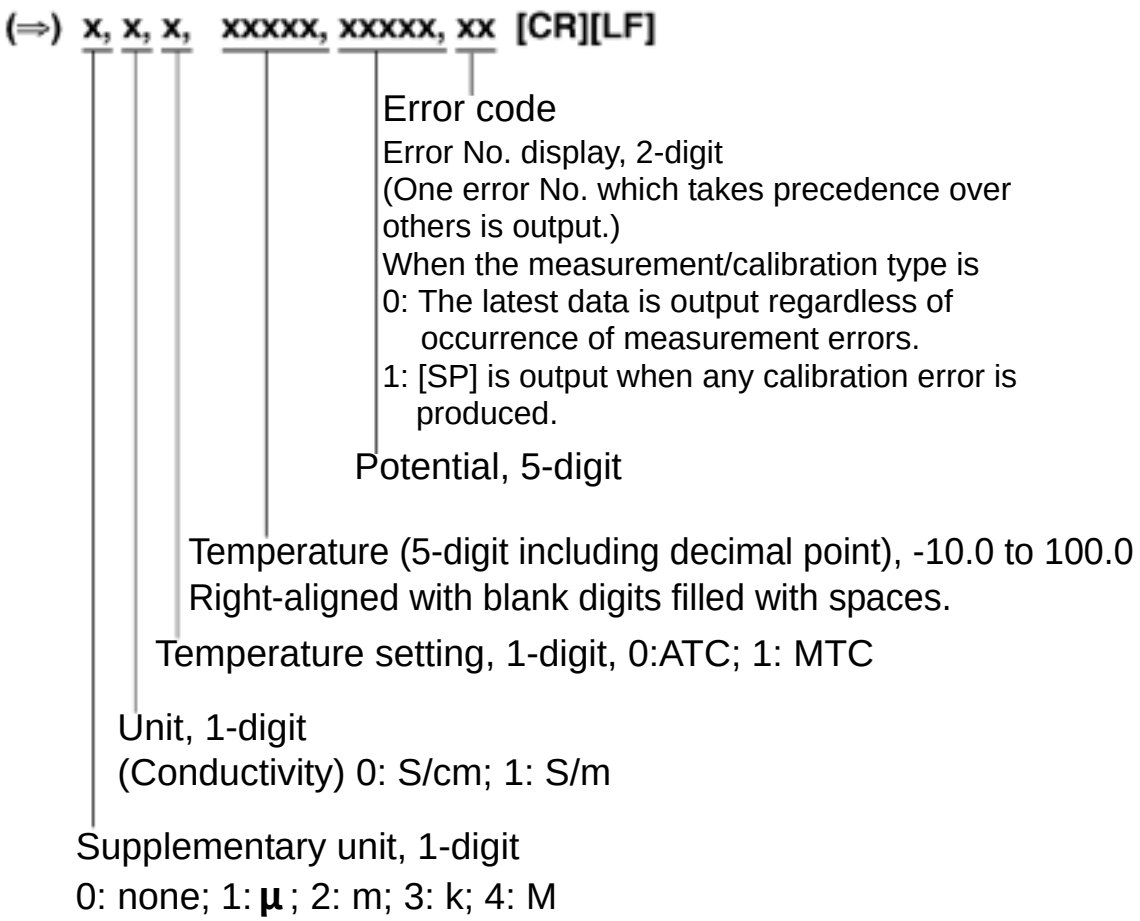
● Request command for memory data and its response

Request command format



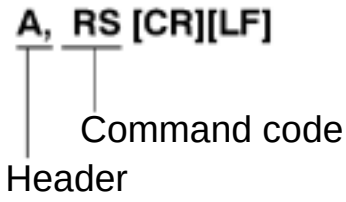
Meter response format



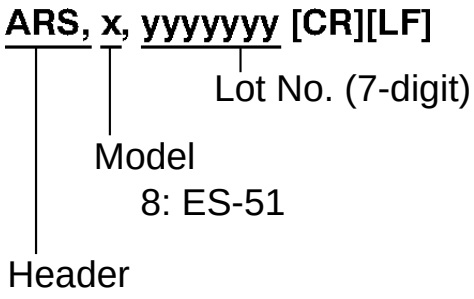

(⇒) x, x, x, xxxxx, xxxxx, xx [CR][LF]
Error code
Error No. display, 2-digit
(One error No. which takes precedence over others is output.)
When the measurement/calibration type is
0: The latest data is output regardless of occurrence of measurement errors.
1: [SP] is output when any calibration error is produced.
Potential, 5-digit
Temperature (5-digit including decimal point), -10.0 to 100.0
Right-aligned with blank digits filled with spaces.
Temperature setting, 1-digit, 0:ATC; 1: MTC
Unit, 1-digit
(Conductivity) 0: S/cm; 1: S/m
Supplementary unit, 1-digit
0: none; 1: μ; 2: m; 3: k; 4: M

● Request command for model and its response

Request command format

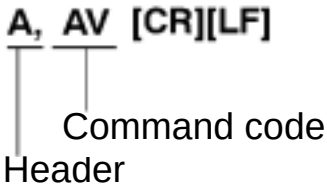


Meter response format

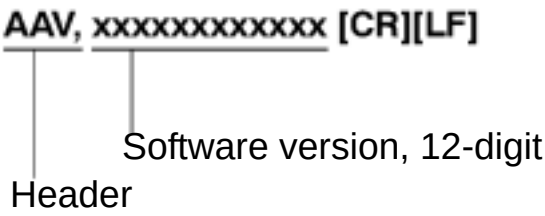


● Request command for software version and its response

Request command format



Meter response format



4.5 Communication example using the HyperTerminal

For reference, communication using the HyperTerminal that comes with Windows is described here.

1. Open the HyperTerminal.

[Start] > [Programs] > [Accessories] > [Communications] > [HyperTerminal]

The HyperTerminal program (Hypertrm.exe) is activated.

2. Make the setting for name, connection, and port.

Select the COM port of the PC currently being used for the port setting.

3. Set the COM port of the PC and set the transmission parameters as follows:

Baud rate: 2400 bps

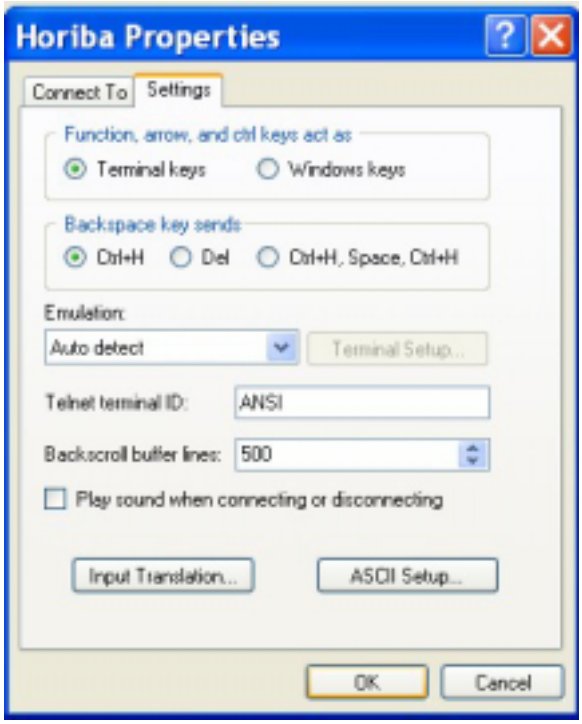
Character length: 8 bits

Parity: none

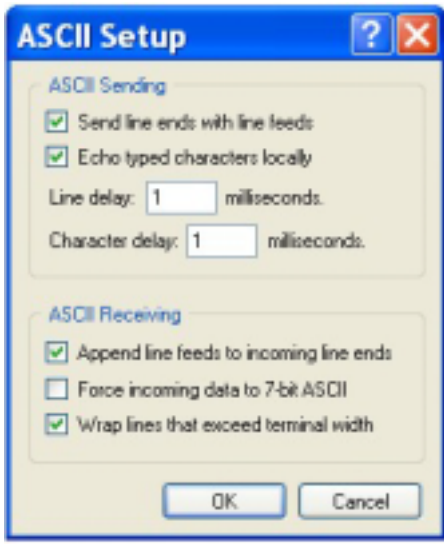
Stop bit: 1 bit

4. Make the settings in the properties dialog box.

[File] > [Properties] > [Settings]



[File] > [Properties] > [Settings] > [ASCII Setup]



Note

You can check the contents transmitted via HyperTerminal by enabling the “Echo typed characters locally (E)” option.

5. Command input

If a command is input, the corresponding response data is sent back.

Command input should be completed within 10 seconds.

Be sure to first set the meter to the On-line mode using the On-line/Off-line command.

Note

Windows® is a registered trademark of Microsoft Corporation.

5 Printer

This chapter explains the printer connection, the times printing takes place, and printing formats.

5.1 Connecting the printer

The following printers are compatible with ES-51.

Printers

- Citizen CBM-910-24RJ100-A (Normal paper)
- Seiko DPU-H245AS-A03A (Heat-sensitive paper)

Attach the printer cable to the printer output connector.

Note

Connect your printer only after turning OFF the power to the main unit of the meter.

Ref.

For the layout of the connector terminals for the printer output cable, refer to “7.5 Pin layout of special cables” page 103.

Note

When a printer is not connected, remove the printer cable from the meter and put the rubber cap securely over serial communication connector.
Be sure to use a cable that matches the printer.

5.2 Printer setting

Set up the printer using these settings:

- Printer output baud rate: 2400 bps
- Bit length: 8 bits
- Parity: none

Setting for a plain paper printer (CBM-910)

Set DIP switch No. 6 to ON and No. 7 to OFF, and prepare the printer paper and ink ribbon. Keep the LF key held down. The printer prints only when the LF key is being pressed.

Setting for a thermal paper printer (DPU-H245AS)

Prepare printer paper and turn ON the power switch with the FEED and CHARGE switches held down. Set the baud rate of the printer to the above value, referring to the instruction manual for the printer.

Start the function setting mode of the printer and change it to the above settings.

5.3 Printer output timing

The printer prints at the following times:

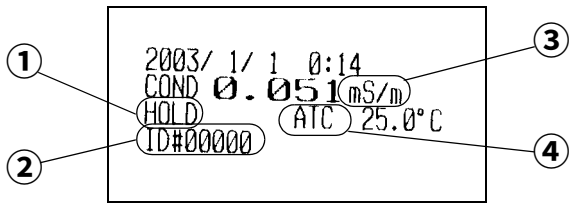
- When pressing the ENTER key after Auto Hold or while the instantaneous value is being displayed in the Measurement mode.
- When the manual data memory storage is performed in the Measurement mode.
- When pressing the ENTER key while in the Data Memory Call mode.
- When calibration or check is performed in the Calibration mode.
- When the ENTER key is pressed in the calibration history display.
- When test printing is selected while in the Maintenance mode.

5.4 Printing format

The following are sample printouts.

5.4.1 When the ENTER key is pressed in the Measurement mode

● COND Measurement mode



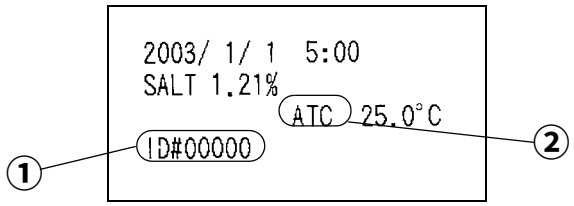
① When the data is the data confirmed with Auto Hold, “HOLD” is shown. Nothing is displayed for the instantaneous value measurement.

② ID#: 5 digits

③ Unit: S/m, mS/m, μS/m, S/cm, mS/cm, μS/cm

④ Temperature compensation setting
Manual mode: MTC
Auto mode: ATC

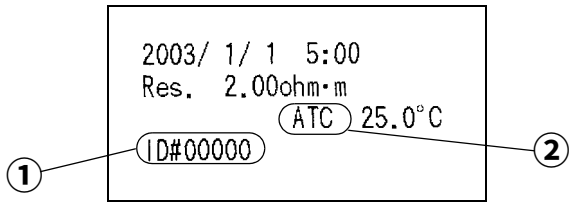
● Salinity Measurement mode



① ID#: 5 digits

② Temperature compensation setting
Manual mode: MTC
Auto mode: ATC

● Resistivity Measurement mode



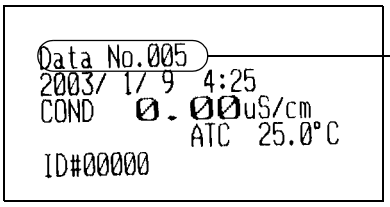
① ID#: 5 digits

② Temperature compensation setting
Manual mode: MTC
Auto mode: ATC

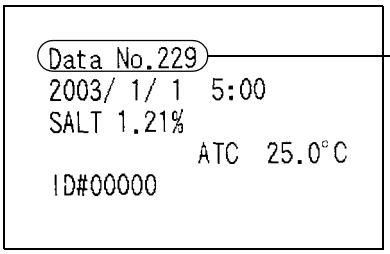
5.4.2 When the manual data memory storage is performed in the Measurement mode

The printer prints the data memory No. in the first line and the data in accordance with the format same with the one in “5.4.1 When the ENTER key is pressed in the Measurement mode” P.74.

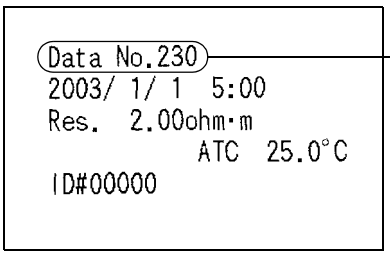
● Example in the COND Measurement mode



● Example in the Salinity Measurement mode



● Example in the Resistivity Measurement mode

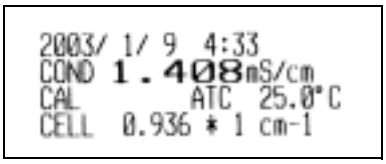


5.4.3 When the ENTER key is pressed in the Data Memory Call screen

The format is the same as that described in “5.4.2 When the manual data memory storage is performed in the Measurement mode” page 75.

5.4.4 When calibration or check is performed in the Calibration mode

COND cell constant calibration



When calibration is performed

5.4.5 Test printing format in the Maintenance mode

6 Maintenance and Troubleshooting

This chapter explains how to perform daily meter maintenance and how to deal with error messages.
Daily maintenance is vital in assuring accurate measurement and preventing breakdowns before they occur. Maintenance of the electrodes is especially important; if ignored, various problems and erroneous measurements may result. This meter is equipped with a convenient error message function. If an error message is displayed, be sure to take appropriate action.

6.1 Conductivity electrode maintenance

Refer to the electrode operation manuals for how to maintain each electrode.

Long-term storage

When an electrode will not be used for a long period of time, store it after performing the following procedure.
Also, perform maintenance on the electrode every three to six months.

1. Remove the electrode from the meter.
2. Use pure (de-ionized) water to wash away any sample solution that may have adhered to the electrode.
3. Wash the inside of the electrode protective cap with pure (ion exchange) water, then, after shaking out the water, fill the cap with enough pure (de-ionized) water to soak the sponge.
4. Place the electrode protective cap on the electrode.

6.2 Troubleshooting

The meter is equipped with a simply error-message function to notify the operator that an operation error or problem with the equipment has occurred. Errors or other problems that occur while in the Measurement mode are announced by an error No. appearing in the lower left-hand corner of the display.

6.2.1 Error message chart

ERR No.	Message	Explanation
01	Memory error	Data cannot be read from or written to the internal memory.
02	Battery voltage low	The battery voltage is low.
03	Electrode stability error	The electric potential did not stabilize within three minutes.
09	Printer error	There is a problem with the printer.
10	Data memory over	The number of data items has exceeded the limit of the memory.
11	Cell constant out of range	Cell constant is out of automatic calculation range.

● ERR No. 01 Memory error

Explanation

Data cannot be read from or written to the internal memory.

Cause	How to solve problem
The conductivity meter does not start operating correctly even after the power is turned ON.	Take the battery from the conductivity meter, and disconnect the AC adapter. Then press the ON/OFF key for about 10 seconds.
The internal IC is defective.	Seek repairs at your nearest retail outlet or HORIBA service station.

● ERR No. 02 Battery voltage low

Explanation

The battery has insufficient voltage.

Cause	How to solve problem
The battery voltage is low. (Battery voltage: 2.2V or less)	Replace the dry-cell battery.

Note

The measured value cannot be guaranteed when ERR No. 02 is displayed.

● ERR No.03 Electrode stability error

Explanation

The electric potential did not stabilize within three minutes.

Cause	How to solve problem
This is caused by the sample solution (when the sample solution is pure water or another solution with low conductivity or the pH concentration or temperature change).	Press the MEAS key again while “HOLD” is either brinking or steadily lit in the display, to measure the sample using instantaneous value measurement.
The electrode is dirty.	Wash the electrode.
The electrode is cracked.	Replace the electrode.
The responsive glass membrane of the electrode has been dry for a long time.	Soak the membrane (on the electrode) in pure (de-ionized) water for 24 hours.
The temperature of the sample solution is fluctuating.	Measure after the sample solution temperature stabilizes.

● ERR No.09 Printer error

Explanation

If a problem occurs with the printer, turn OFF the power to the meter, perform the appropriate measure below, and turn the power to the meter back ON.

Cause	How to solve problem
The printer paper is jammed.	Remove the jammed paper.
There is no printer paper.	Load the printer with paper.
There is a problem with the printer connection.	Reconnect the printer after making sure there is nothing wrong with the connector parts.
The printer is defective.	Replace the printer.

● ERR No.10 Data memory over

Explanation

The number of data items has exceeded the limit of the memory.

Cause	How to solve problem
Memory over	Delete data stored in the memory after confirming their contents.

● ERR No.11 Cell constant out of range

Explanation

The cell constant is out of the range of 0.7 to 1.3. Delete data stored in the memory after confirming their contents.

Cause	How to solve problem
COND electrode is at the end of its useful life.	Replace the electrode.
Improper standard solution	Prepare new standard solution.

6.2.2 More troubleshooting

This section explains how to respond to various symptoms of trouble that are not indicated by an error number.

● Nothing shows up on the display when the power is turned ON

Cause	How to solve problem
No batteries	Place batteries in the meter.
The batteries are loaded with the poles reversed.	Re-insert the batteries with the poles correctly oriented.
The battery voltage is low.	Remove the old batteries and correctly insert new dry-cell batteries. Or connect the unit to the optional AC adapter.

● The indicated value fluctuates

When there is a problem with the electrode...

Cause	How to solve problem
There are air bubbles on the electrode.	Shake the electrode to remove the air bubbles.

When there is a problem with the main unit of the meter...

Cause	How to solve problem
There is a motor or other device causing electrical interference.	Move the meter to a place where it is not subject to dielectric effects. Be sure to ground devices that are using commercial electricity.

Cause	How to solve problem
The electrode is not connected correctly.	Connect the electrode correctly.

When there is a problem with the sample solution...

Cause	How to solve problem
Some effects of the sample	Determine if this is the cause by measuring with a stable standard solution.

● The response is slow

Cause	How to solve problem
Some effects of the sample	Response time may slow down, depending on the properties of the sample solution.

● The indicated value does not change, or there is absolutely no response

Cause	How to solve problem
The key-lock function is ON.	Turn the power OFF, and then turn it back ON again.
The system is locked.	Turn the power OFF, and then turn it back ON again.
The electrode connector is not attached correctly.	Attach the electrode connector correctly.
Conductivity meter is defective.	Contact your local HORIBA distributor.

● The measured value is blinking

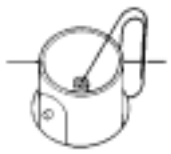
The measured conductivity value exceeds the measurement parameters (when conductivity value is displayed).

Display range: 0.00 – 19.99 (when cell constant is 100 m^{-1})

Cause	How to solve problem
The sample solution is inappropriate.	Change to a sample solution with properties within the measurement range.
The electrode cable has been severed.	Replace the electrode.
The main body of the meter is defective.	Check the point described below.

Check this point

As shown in the diagram, use a jumper wire or bent paper clip to short the meter by touching both the center pin and some metal part in the electrode connector.
If the flaching measured value disappears when this done, the meter is nomal.



● The temperature display is blinking.
The temperature display does not change from 25ºC.

The temperature measurement exceeds the measurement range.

Measurement range: -10 – 100.0ºC

Cause	How to solve problem
The temperature of the sample solution exceeds the measurement range.	Check the temperature of the sample solution and change to a sample solution that has a temperature within the measurement range.
The thermistor connection within the electrode is severed or shorted.	Measure the resistance of the temperature sensor connector. If it is 50 kΩ or more at room temperature, replace the electrode.
The electrode connector is not attached properly.	Attach the electrode connector properly, so that the O-ring on the temperature connector disappears from sight.
The main unit of the meter may be defective.	In Temperature Display Calibration mode (See “ ● Temperature zero adjustment [item No. 02]” page 43), check whether or not the “Minus” display appears, regardless of whether or not there is a temperature connector.
There is a problem with the setting for the temperature display calibration mode (see page 43).	Initialize the settings (see page 46).

● When the printer will not print even though it is connected

Check the following points:

- Is the printer turned ON?
- Has a printer error occurred?
- Is there printing paper? Has the paper jammed?
- When running a test print according to the manual, does it print out correctly?

7 Reference

This chapter provides a simple compilation of information for those who would like to know about the functions of the main unit of the meter and other measurement principles in greater detail.
It also serves as a reference for spare and optional parts.

7.1 Conductivity measurement

● Electrode sensitivity check

The cell constant of a conductivity electrode may vary, depending on the sample solution. Check the cell constant by measuring conductivity, using the following solutions, at least once every three months.

Cell constant	Electrode model	KCl standard solution	KCl Weight	Solution temp.	Conductivity value
SI units 100 m^{-1} (former unit designation 1 cm^{-1})	9382 -10D	0.01 mol/L	0.7440 g	0ºC	77.4 mS/m (0.774 mS/cm)
				18ºC	122.0 mS/m (1.220 mS/cm)
				25ºC	140.8 mS/m (1.408 mS/cm)

Prepare the potassium chloride standard solution (KCl 0.01 mol/L) using the procedure below.
In addition, if an error of 5% of more compared to the above values occurs, calibrate the cell constant (See page 22).

● Preparing potassium chloride standard solution

How to prepare solution

Dry the potassium chloride powder (“superior quality” commercial potassium chloride or better) for two hours, at 105 ºC, then cool it in a desiccator. Measure out the above-listed amount of potassium chloride into a beaker and dissolve it in de-ionized water. Then, pour this solution into 1-liter volumetric flask and add de-ionized water until the indication line.

● Measuring conductivity

"Conductivity" is an index that expresses the ease with which electric current flows through a material. Conductors are categorized either as "electron conductors" (such as metals and other substances which use free electrons to conduct electricity) or "ion conductors" (such as electrolytic solution or fused salt, which use ions to conduct electricity). This section deals with the kind of conductivity that pertains to ions, especially the conductivity of electrolytic solution that uses water as the solvent. As shown in Fig. 1, two pole plates with an area A (expressed in m^2) are positioned parallel to each other, separated by distance l (expressed in m). Then solution is poured into the cell until it is full and alternating current is run between the plates.

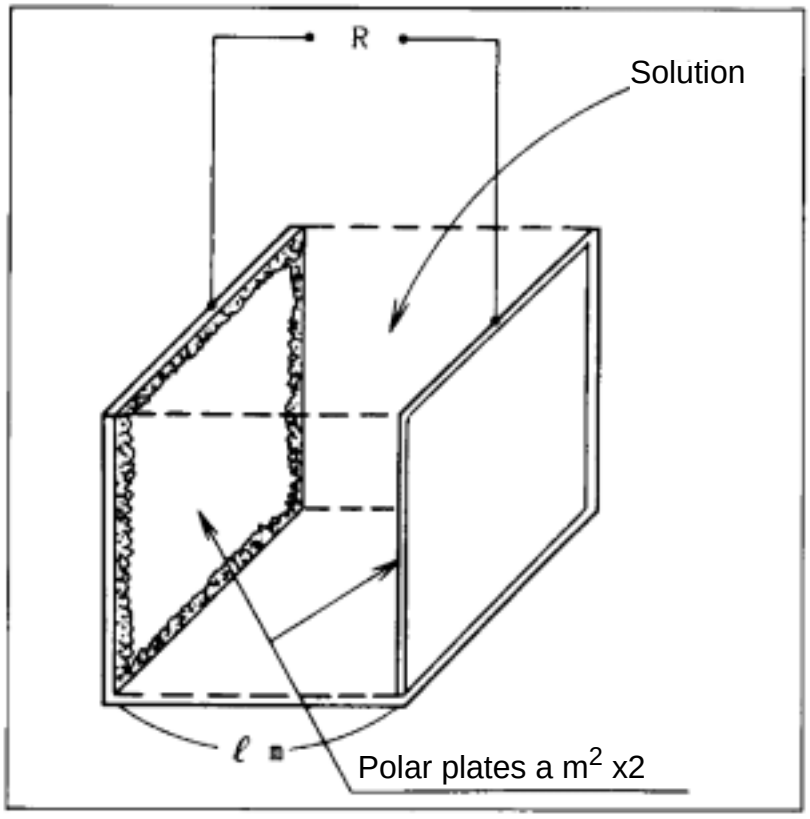


Fig. 1 Conductivity cell example

Each positive and negative ION in the solution will migrate toward the oppositely charged pole. The result is that current flows through the solution by means of ION conductivity. When this occurs, resistance R (expressed

in **Ω**) is in inverse proportion to the area A (expressed in m^2) of the pole plates, as is the case with metal and other conductors, and is proportional to the distance l (expressed in m) between the two pole plates. These relationships are expressed by equation 1, below.

R = r x l/a = rJ (Equation 1)
R: Resistance (Ω)
r: Specific resistance (Ω·m)
a: Pole plate area (m^2)
l: Distance between pole plates (m)
J: Cell constant (m^{-1})

Specific resistance (expressed in Ω·m) is an index that indicates the difficulty with which current flows and is a constant determined according to the solution. The inverse of r (expressed in Ω·m), which is L (and is equal to 1/r), is called the “specific conductivity” and is widely used as an index to express the ease with which current flows. Specific conductivity L is generally referred to as simply “conductivity” and is expressed in units of S/m.
Inserting conductivity L (expressed in S/m) into equation 1 results in equation 2, below.

R = J/L (Equation 2)

As is clear from equation 2, when a conductivity cell having a cell constant J of 1 m^{-1} is used (in other words, when a conductivity cell having two pole plates that each have an area a of 1 m^2 and are positioned parallel to each other such that the distance l between the two plates is 1 m is used) the inverse of the resistance R of the solution (expressed in Ω) between both pole plates is the conductivity. Conductivity is defined in this way, but it changes according to the temperature of the solution.
The conductivity of a solution is generally expressed as the value when the solution is 25ºC.

● New units (SI units)

New measurement units, called SI units, have come into use in recent years. Accordingly, the meter also uses SI units. The following conversion table is provided for people who are used to using the conventional kind of conductivity meter. Note that along with the change in unit systems, the measurement values and cell counts have also changed.

	Former units	⇒	SI units
Cell constant	1 cm^{-1}	⇒	100 m^{-1}
	0.1 cm^{-1}	⇒	10 m^{-1}
	10 cm^{-1}	⇒	1000 m^{-1}
Measurement value	10 μS/cm	⇒	1 mS/m
	1 mS/cm	⇒	100 mS/m
	100 mS/cm	⇒	10 S/m

● Temperature compensation

The conductivity of a solution generally varies greatly, depending on the temperature of the solution. Because the conductivity of a solution is based on its ION conductivity, as explained above, the higher the temperature of the solution the more active its ions and the higher its conductivity. Using a given temperature as the standard (and calling that the standard temperature), the “temperature coefficient” expresses how much change (expressed in %) occurs in conductivity when the temperature of the solution changes by 1ºC. The temperature coefficient is expressed in units of “%/ºC (standard temperature).” This temperature coefficient is found by assuming that the conductivity of the sample changes linearly in relation to temperature, whereas the change in conductivity of an actual sample, strictly speaking, follows a curve. The shape of this curve changes, depending on the kind of sample being measured. Most solutions, however, are said to generally have a temperature coefficient of 2%/ºC (25ºC standard), within a range where the size of the temperature change is not very large.

The meter is equipped with a built-in automatic temperature conversion function, enabling them to automatically calculate and display, based on the actual temperature measurement, the conductivity of a sample at 25ºC, using a temperature coefficient of 2%/ºC.

● Conductivity and temperature coefficients for various solutions

The following table shows the conductivity (converted to 25 ºC) and the temperature coefficient at that time, for various kinds of solution.

Sub-stance	Temp. (ºC)	Conc. (wt%)	Cond. (S/m)	Temp. coef. (%/°C)	Sub-stance	Temp. (ºC)	Conc. (wt%)	Cond. (S/m)	Temp. coef. (%/°C)
NaOH	15	5	19.69	2.01	NaCl	18	5	6.72	2.17
		10	31.24	2.17			10	12.11	2.14
		15	34.63	2.49			15	16.42	2.12
		20	32.70	2.99			20	19.57	2.16
		30	20.22	4.50			25	21.35	2.27
		40	11.64	6.48	Na_2SO_4	18	5	4.09	2.36
KOH	15	25.2	54.03	2.09			10	6.87	2.49
		29.4	54.34	2.21			15	8.86	2.56
		33.6	52.21	2.36	Na_2CO_3	18	5	4.56	2.52
		42	42.12	2.83			10	7.05	2.71
NH_3	15	0.1	0.0251	2.46			15	8.36	2.94
		1.6	0.0867	2.38	KCl	18	5	6.90	2.01
		4.01	0.1095	2.50			10	13.59	1.88
		8.03	0.1038	2.62			15	20.20	1.79
		16.15	0.0632	3.01			20	26.77	1.68
HF	18	1.5	1.98	7.20			21	28.10	1.66
		4.8	5.93	6.66	KBr	15	5	4.65	2.06
		24.5	28.32	5.83			10	9.28	1.94
HCl	18	5	39.48	1.58			20	19.07	1.77
		10	63.02	1.56	KCN	15	3.25	5.07	2.07
		20	76.15	1.54			6.5	10.26	1.93
		30	66.20	1.54			—	—	—

Sub-stance	Temp. (ºC)	Conc. (wt%)	Cond. (S/m)	Temp. coef. (%/°C)	Sub-stance	Temp. (ºC)	Conc. (wt%)	Cond. (S/m)	Temp. coef. (%/°C)
H_2S0_4	18	5	20.85	1.21	NH_4Cl	18	5	9.18	1.98
		10	39.15	1.28			10	17.76	1.86
		20	65.27	1.45			15	25.86	1.71
		40	68.00	1.78			20	33.65	1.61
		50	54.05	1.93			25	40.25	1.54
		60	37.26	2.13	NH_4NO_3	15	5	5.90	2.03
		80	11.05	3.49			10	11.17	1.94
		100.14	1.87	0.30			30	28.41	1.68
		—	—	—			50	36.22	1.56
HNO_3	18	6.2	31.23	1.47	$CuSO_4$	18	2.5	10.90	2.13
		12.4	54.18	1.42			5	18.90	2.16
		31	78.19	1.39			10	32.00	2.18
		49.6	63.41	1.57			15	42.10	2.31
		62	49.64	1.57	CH_3COOH	18	10	15.26	1.69
H_3PO_4	15	10	5.66	1.04			15	16.19	1.74
		20	11.29	1.14			20	16.05	1.79
		40	20.70	1.50			30	14.01	1.86
		45	20.87	1.61			40	10.81	1.96
		50	20.73	1.74			60	4.56	2.06

7.2 Specifications

● Measurement target

Target	Item	Description
Temp.	Measurement principle	Thermistor
	Measurement range	0.0 – 100.0 ºC
	Resolution	0.1 ºC
	Repeatability	±0.1 ºC ±1digit
Conductivity	Measurement principle	2 AC electrode
	Measurement range	Cell constant 100 m^{-1} 0.000 S/m – 19.99 S/m Cell constant 10 m^{-1} 0.0 μS/m – 1.999 S/m Cell constant 1000 m^{-1} 0.00 mS/m – 1999.9 S/m
	Resolution	0.05% of full scale
	Repeatability	±0.5% ±1 digit of full scale
Salinity concentration	Measurement principle	2 AC electrode
	Measurement range	0 – 4%
	Resolution	0.01 %

Target	Item	Description
Resistivity	Measurement principle	2 AC electrode
	Measurement range	Cell constant 100 m^{-1} 5.00 Ω•m – 199.9 kΩ•m Cell constant 10 m^{-1} 50.0 Ω•m – 1.999 MΩ•m Cell constant 1000 m^{-1} 0.500 Ω•m – 19.99 kΩ•m
	Resolution	0.05% of full scale
	Repeatability	±0.5% ±1 digit of full scale

● Items in common among meter models

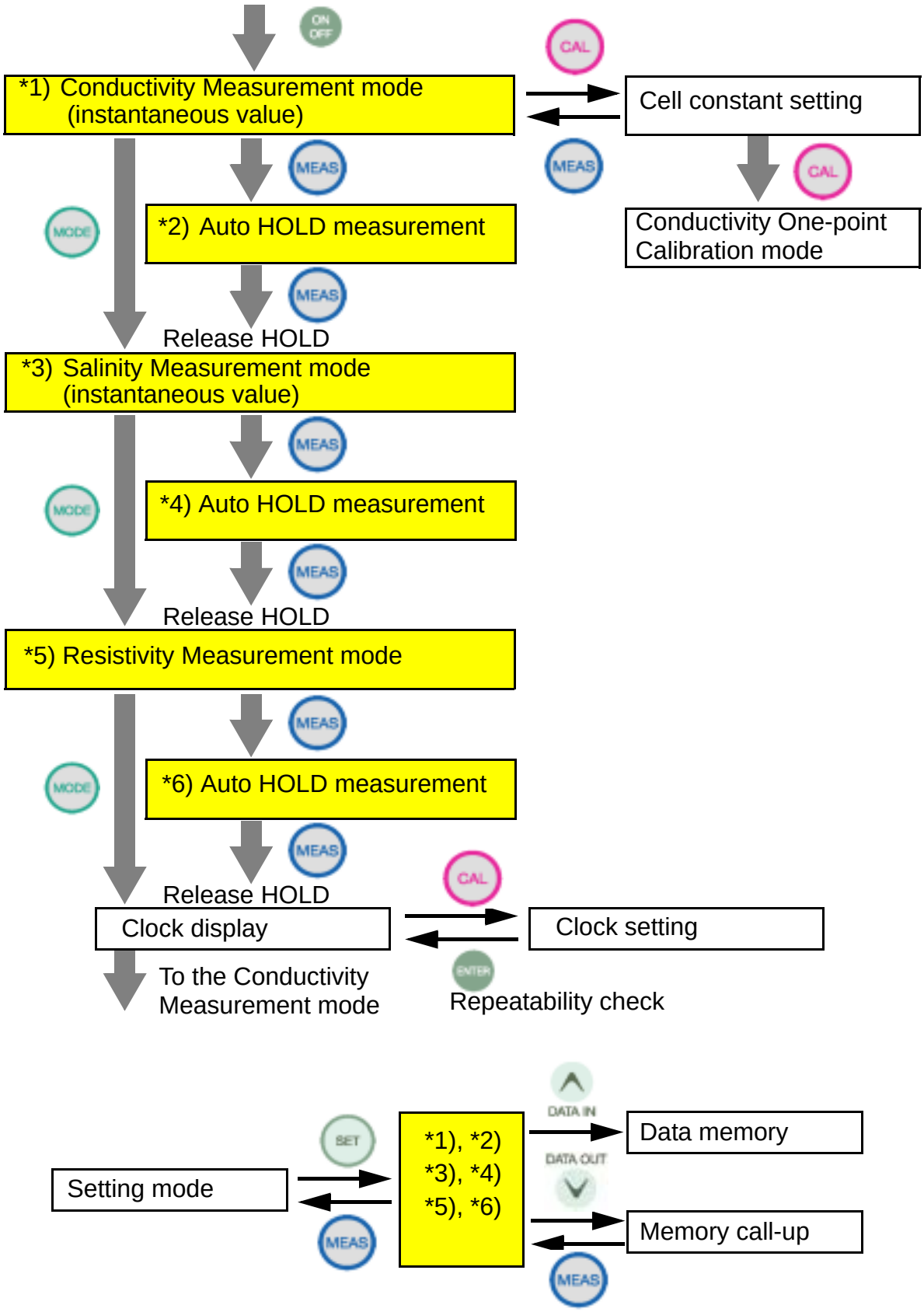
Data memory capacity	Max. 300 pieces of data
Power	Dry cell batteries type:AA alkaline with automatic power OFF function
Ambient temperature	0 – 45 ºC
Dimensions	170(H) × 80(W) × 40(D) mm
Mass of main unit (including batteries)	300 g

7.3 Default settings

Category	Item	Default values
Common setting	Temperature compensation	Automatic temperature compensation
	Manual temperature compensation	25 ºC
	Automatic power OFF	Approx. 30 min (ON)
	Sample ID	00000
	Auto data memory	OFF
Conductivity	Unit	S/m
	Temperature coefficient	2.0 %/ºC (ON)
	Cell constant	1.0 x 100 m^{-1}

7.4 Operation flowcharts

The following flowcharts summarize conductivity meter operations.



7.5 Pin layout of special cables

7.5.1 RS-232C communications cable

Meter main unit		Printer
MINI DIN8M		D-SUB 9-PIN
2;CTS	—	7;RTS
3;TXD	—	2;RXD
4;GND	—	5;GND
5;RXD	—	3;TXD

7.5.2 Cable for CITIZEN printer

CBM-910-24RJ100-A

Meter main unit		Printer
MINI DIN8M		D-SUB 25-PIN
2;CTS	—	20;BUSY
3;TXD	—	3;RXD
4;GND	—	7;GND
5;RXD	—	2;TXD

7.5.3 Cable for SEIKO printer

DPU-H245AS-A03A

Meter main unit		Printer
MINI DIN8M		D-SUB 25-PIN
2;CTS	—	8;BUSY
3;TXD	—	3;DATA
4;GND	—	5;GND
5;RXD	—	2;OPEN

7.6 Spare and optional parts

This section lists spare and optional parts for the meter. These parts are available through HORIBA distributors. Place an order specifying their name, model, and part number.

7.6.1 Spare parts list

COND electrode for D-54

Water-proof type conductivity electrode	9382-10D	9096000300	Water-proof Cell constant 100 m^{-1}
Conductivity electrode	3551-10D	9056000800	For low conductivity Cell constant 10 m^{-1}
	3553-10D	9056001000	For high conductivity Cell constant 1000 m^{-1}
Flow-through type conductivity electrode	3561-10D	9056001100	For low conductivity Cell constant 10 m^{-1}
	3562-10D	9056001200	General purpose Cell constant 100 m^{-1}
	3573-10C	9056001300	For high conductivity Cell constant 1000 m^{-1}
	3574-10C	9056001400	For micro samples Cell constant 1000 m^{-1}

Note

Actual cell constants vary within ±10% of the above values.

7.6.2 Options

Part name			Part number	Remarks
AC adapter for the meter	AC adapter		9096003100	Be sure to purchase the cable when purchasing the AC adapter.
	Cable	For Japan	9096003200	
		For US	9096003300	
		For Europe	9096003400	
Plain paper printer	Printer	For Japan	9096003500	
		For US	9096003600	
		For Europe	9096003700	
	Printer cable		9096003800	
	Roll paper		9096003900	
	Ink ribbon		9096004000	
Serial cable			9096004800	
Data collection software			9096005000	For PC
Soft case			9096005100	
Strap			9096005200	For the meter
Stand for electrode			9096002700	
Stand arm			9096002800	

For any question regarding this product, please contact your local agency, or inquire from the Customer Registration website (www.horiba.co.jp/register)

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