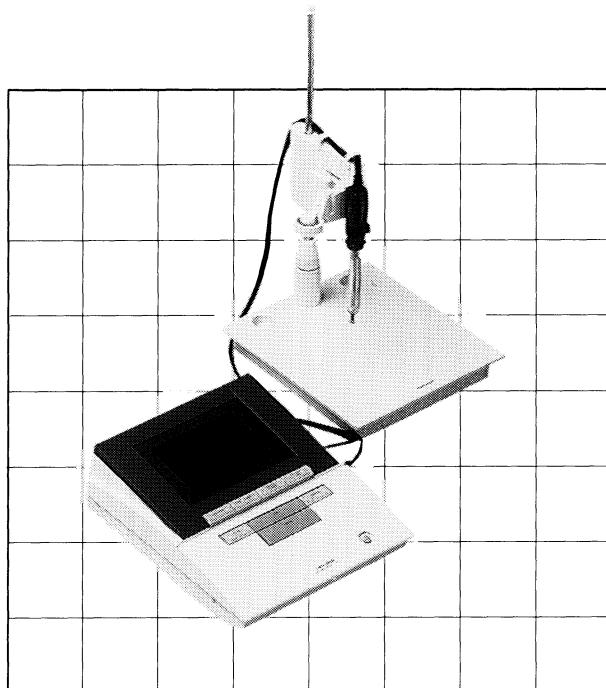


HORIBA

pH Meters F Series

F-21

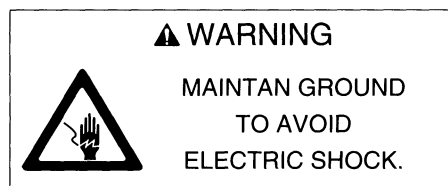


Instruction Manual

HORIBA, Ltd.

WARNING

This equipment has been tested and found to comply with the 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 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.



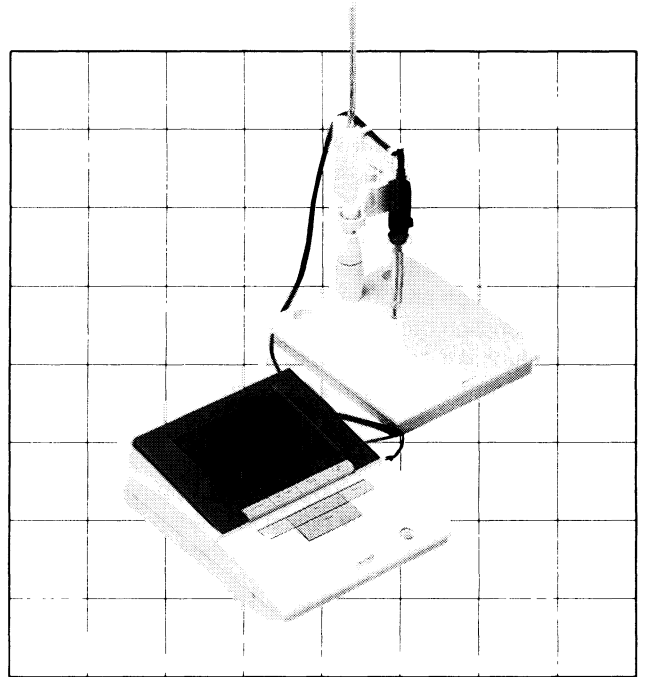
Copyright © 1994 by HORIBA, Ltd.

No part of this *Instruction Manual* may be reproduced or altered in any way without written permission from HORIBA, Ltd.

The information contained in this *Instruction Manual* is subject to change without notice, as improvements are made in specifications and does not represent a commitment on the part of HORIBA, Ltd.

pH Meters F Series

F-21



Instruction Manual

HORIBA

CODE : I0041777000C

Preface

- This Instruction Manual explains the operation of the pH-meter F series.
- Be sure to read this Manual before using the pH meter. Please be sure to safely store the Instruction Manual so it is readily available whenever necessary.
- The information in this Instruction Manual is subject to change without notice as improvements are made in specifications, and does not represent a commitment on the part of HORIBA, Ltd.

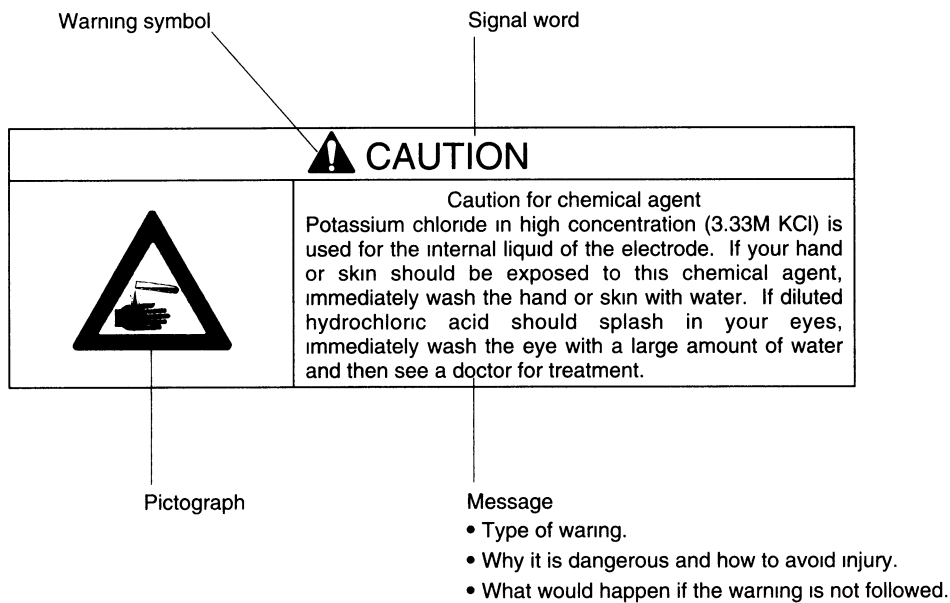
HORIBA's Warranty and Responsibility

- The F-series pH meter delivered to you is covered by HORIBA's warranty for a period of one (1) year. If any malfunction attributable to Horiba should occur during this period, necessary repairs or replacement of parts shall be made free of charge by HORIBA. The warranty does not cover the following:
 - Any malfunction attributable to improper operation of the F-series pH meter.
 - Any malfunction attributable to repair or modification by any party not authorized by HORIBA.
 - Any malfunction attributable to the use of the F-series pH meter in an improper operating environment.
 - Any malfunction attributable to an accident or mishap not involving HORIBA.
 - Any malfunction attributable to a natural disaster.
 - Wear and tear to parts, the exchange of accessories, or the use of any parts not specified by HORIBA.
- In preparing this Manual, every attempt has been made to include the latest equipment changes and specifications. However, please keep in mind that our equipment evolves rapidly as improvements are made, and this version of the Manual may not necessarily reflect all changes in product design. HORIBA reserves the right to modify its products at any time without necessarily including these changes in the documentation.
- HORIBA is not responsible for any damage that may occur from any information other than that included in this document.

Safety Pages

Warning Levels

- This Manual classifies warnings into four types: Warning symbols, Signal words, Messages, and Pictograms. Be sure to follow the instructions given by each of these types of warnings.





- The following signal words are used.

CAUTION A potentially dangerous situation that may result in a non-fatal injury. "CAUTION" is also used throughout the manual to indicate other unsafe actions.



General Product Notices

- You may receive an electric shock if you remove any cover you are not instructed to open or if you disassemble the unit.
- Do not disassemble or modify the product.
- Some measuring materials may be hazardous. Be sure to understand the physical properties of the materials used for measuring when using this equipment.
- Make sure the voltage in your area matches the requirements of the machine before turning ON the power switch.



Reference Solution



 CAUTION	
	<p>Caution for chemical agent Potassium chloride in high concentration (3.33M KCl) is used for the internal liquid of the electrode. If your hand or skin should be exposed to this chemical agent, immediately wash the hand or skin with water. If diluted hydrochloric acid should splash in your eyes, immediately wash the eye with a large amount of water and then see a doctor for treatment.</p>

Glass



 CAUTION	
	<p>Caution for injuries: A broken glass fraction can injure you. The support tube and tip of the electrode are made of glass. Take care that they do not not brake.</p>

Battery

 CAUTION	
	<p>Caution for burst/fire: The battery can burst or cause ignition. Never disassemble, heat, short circuit, or charge the removed battery; or throw it into fire.</p>

 CAUTION	
	<p>Caution for swallowing: Swallowing the removed battery is extremely dangerous. Never place the removed battery in a place accessible to children. If someone should swallow the battery, he or she must immediately see a doctor for treatment.</p>

Diluted hydrochloric acid

 CAUTION	
	Caution for chemical agent Diluted hydrochloric acid can irritate hands and skin if it makes contact with them. If your hand or skin should be exposed to this chemical agent, immediately wash the hand or skin with water. If diluted hydrochloric acid should splash in your eyes, immediately wash the eye with a large amount of water and then see a doctor for treatment.

If You Do Not Follow the Procedures and Cautions

HORIBA assumes no responsibility for matters which occur due to failure to follow the instructions and WARNINGS described in the manual.

Organization

The F-21 series desktop type pH meter allows easier operations and provides diversified application functions. It ensures highest performance for various pH measurements to meet your requirements. This instruction manual describes the complete sequence from preparations to actual operations. Since each capability is covered independently, any function can be quickly referenced whenever necessary. This instruction manual is applicable for F-21 and F-21 II.

Organization of This Manual

This instruction manual is organized as follows:

CHAPTER 1 OVERVIEW AND FUNCTIONS

The overview and simple functions of the F-21 series are described together with the preparations before measurement.

CHAPTER 2 BASIC OPERATIONS

The basic operation flow of the F-21 series is described.

CHAPTER 3 OTHER FUNCTIONS

Various functions of the F-21 series are described.

CHAPTER 4 DAILY MAINTENANCE AND INSPECTION

The daily maintenance and inspection of the F-21 series are described.

CHAPTER 5 RS-232C SPECIFICATIONS

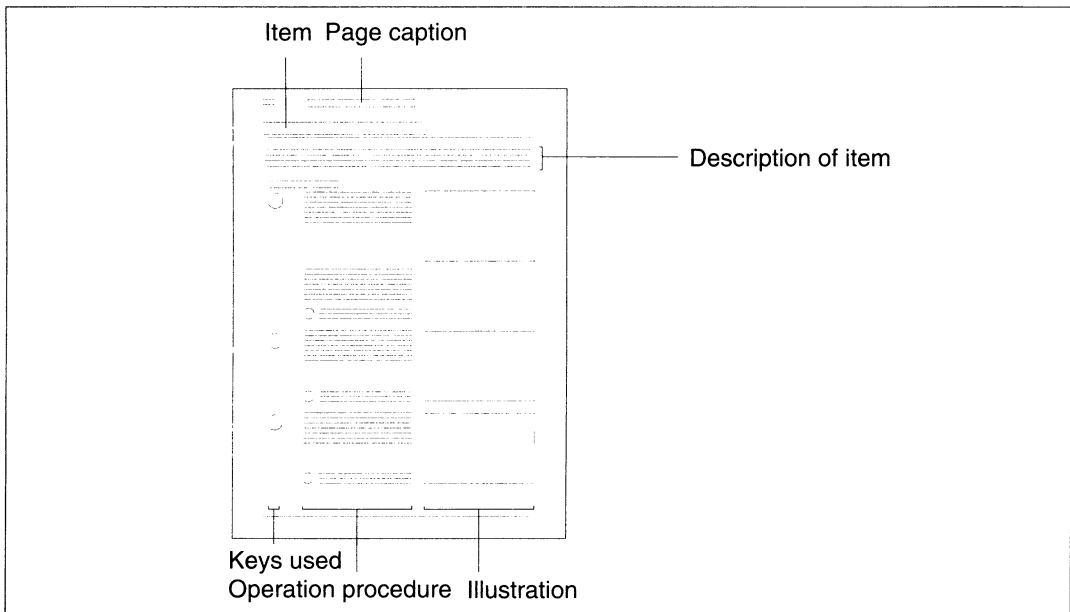
The RS-232C communication procedure and the communication commands are described.

CHAPTER 6 PRINTER (EXTRA-COST OPTION)

The connections and usage of the printer are described.

CHAPTER 7 APPENDIX

Conventions of This Manual



Conventions in notation

⋄ It indicates blinking in the screen.

Checking Contents of the Package

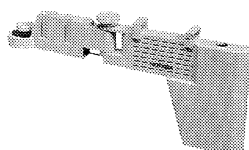
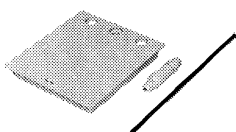
The system package contains the following accessories. Confirm that none of the items listed below is missing or damaged.

pH meter: 1 set

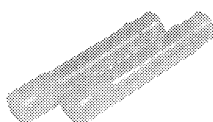
Electrode (9610-10D) 1 pc



Electrode stand: 1 set



Electrode protective cap (polyethylene): 2 pcs



Buffer set (101-S)



pH 4 250mL: 1
pH 7 500mL: 1
pH 9 250mL: 1
Reference solution (300) 250mL: 1
Filter: 1 pc

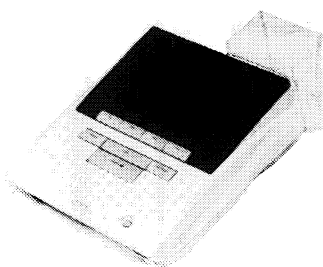
For some regions or countries, the package contains the reference solution only.

AC adapter (AC-10): 1



Instruction manual: 1 copy

Dustproof lid: 1



Precautions

- **Do not allow water or other liquids to come in contact with the main body of the pH meter.**

Liquids can damage the instrumentation. To clean the pH meter, wipe with a soft cloth such as silicon cloth.

- **Do not touch electrode and pH meter connectors with dirty hands, or allow them to get wet.**

High insulation is required for the electrode connectors and the pH meter. If they become dirty or come in contact with water, these insulating properties may deteriorate resulting in unstable readings or erroneous measurements. In certain situations the electrode itself may suffer irreparable damage.

- **Do not strike the electrode.**

The tip of the electrode is a thin glass membrane, so it must be handled with care. If it is knocked against a hard object or handled in a rough manner, it may break or crack, making measurements and calibration impossible.

The electrode protecting cap should always be attached when the electrode is not in use.

- **Do not use the pH meter in the following situations:**

- where ambient temperature is outside the range 5 to 45°C;
- in dusty places;
- in humid places;
- in places subject to strong vibration;
- near a large electric motor or transformer;
- in places subject to corrosive gases.

- **Do not strike the pH meter.**

- **Do not operate the switches with a hard object such as a pencil or metal rod.**

- **Use the AC adapter Model AC-10 for exclusive use.**

- **When not using the adapter, remove it from the power outlet.**

CONTENTS

Chapter 1

OVERVIEW AND FUNCTIONS

Functions	2
Names of Parts	3
Keys and Display	6
Assembling Electrode Stand	11
Connecting the Electrode and the Power Source	12
Replacing the Back-up Battery	14

Chapter 2

BASIC OPERATIONS

Measurement Flow	16
Basic Operations	18

Chapter 3

FUNCTIONS

Calibration and Measurement in the Manual Mode	28
Calibration Using Standard Buffers other than the Specified Ones	31
mV Measurement Function	32
Automatic Temperature Compensation (ATC) and. Manual Temperature Compensation (MTC)	33
Temperature Conversion Function	34
Clock & Calendar	36
Date and Time of Last Calibration	37
Data Memory Function	38
Data Output from Recorder	40

Chapter 4

DAILY MAINTENANCE AND TROUBLESHOOTING

Maintenance of the Electrode	42
Error Numbers	44
Other Troubles	47

Chapter 5

RS-232C INTERFACE

Points to Check Before Use	50
RS-232C Related Commands	51
On-Line Operation Commands	52
Command to Specify Data	55
Command to Request Data and Response from pH Meter	57
Sample Program	62
RS-232C Specifications	66

Chapter 6

PRINTER

Installing the Printer Unit (EXTRA-COST OPTION)68
Specifications of Printer Output69

Chapter 7

APPENDIX

Concerning pH Measurements74
Measuring ORP (Oxidation-Reduction Potential)78
Supplies81
Specifications82

OVERVIEW AND FUNCTIONS

Functions	2
Description of Functions	2
Names of Parts	3
Main Unit	3
Electrodes	5
Keys and Display	6
Control Keys	6
Reading the Display	8
Assembling Electrode Stand	11
Connecting the Electrode and the Power Source	12
Removing the Connector Lid	12
Connecting the Electrode	12
Snapping the Sensor Holder	13
Connecting the Power Source	13
Replacing the Back-up Battery	14

Functions

The F-21 incorporates various functions including temperature-based conversion, time display, and data processing in addition to its basic capabilities of measuring pH and mV values.

Description of Functions

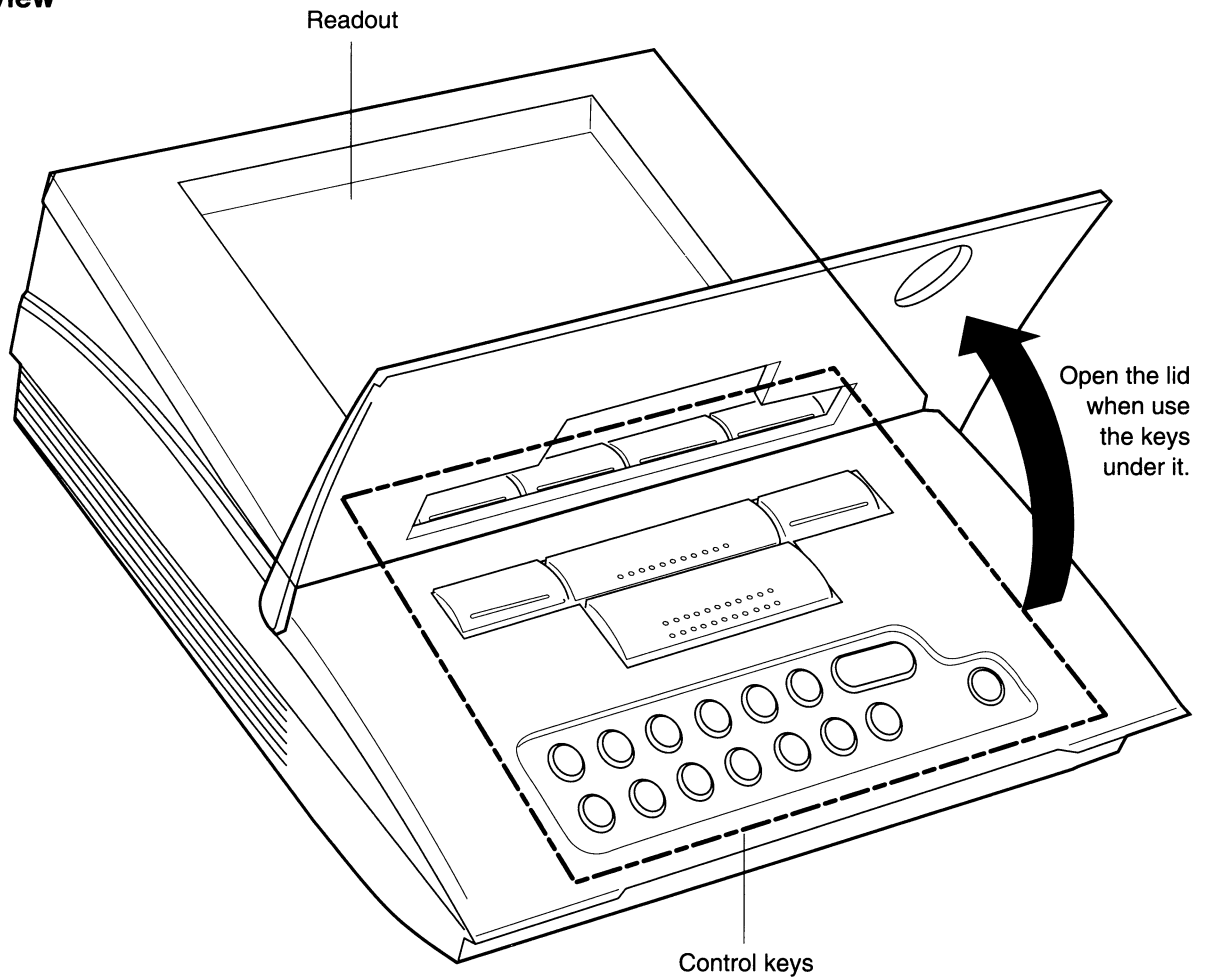
Function	Description
pH measurement	pH measurements are possible.
mV measurement	mV measurements are possible.
Automatic identification of pH standard buffers	Standard buffers of pH 2, 4, 7, 9*, and 12 can be automatically identified to allow up to 5 points to be calibrated.
Other buffer calibration	Calibration can be performed with only one arbitrary pH value in addition to five standard buffers of pH 2, 4, 7, 9*, and 12.
Error display	Simple error messages indicating missing operation or malfunctions.
Calibrated standard	For calibration using a pH standard solution, the type of that solution is displayed.
AUTO HOLD	The stability of electric potential is automatically determined to hold the reading.
Selectable display resolution (Not applicable for F-21_{II})	The number of digits used to display pH values can be changed.
Relative mV	In the mV measurement, any arbitrary electric potential can be set to the zero point (0 mV).
Temperature compensation, automatic	The sensor incorporated in the electrode automatically performs temperature compensation on the electromotive force for the electrode. (pH and ion measurements)
manual	Temperature compensation is available by specifying the temperature of the sample solution via the numeric keypad.
Temperature conversion	Any of the measured pH values can be converted to the pH value at the specified temperature (25°C).
Calibration date display	Stores and displays the date and time of the last calibration.
Data memory	Up to 99 measured data entries (values and temperatures) can be output to the printer.
Time display	Year, month, day, and time (hour, minute, and second) can be displayed or output to the printer (extra-cost option).
Recorder output	The use of RS-232C port allows you to bi-directionally communicate with a computer.

* This becomes 10 for some regions or countries.

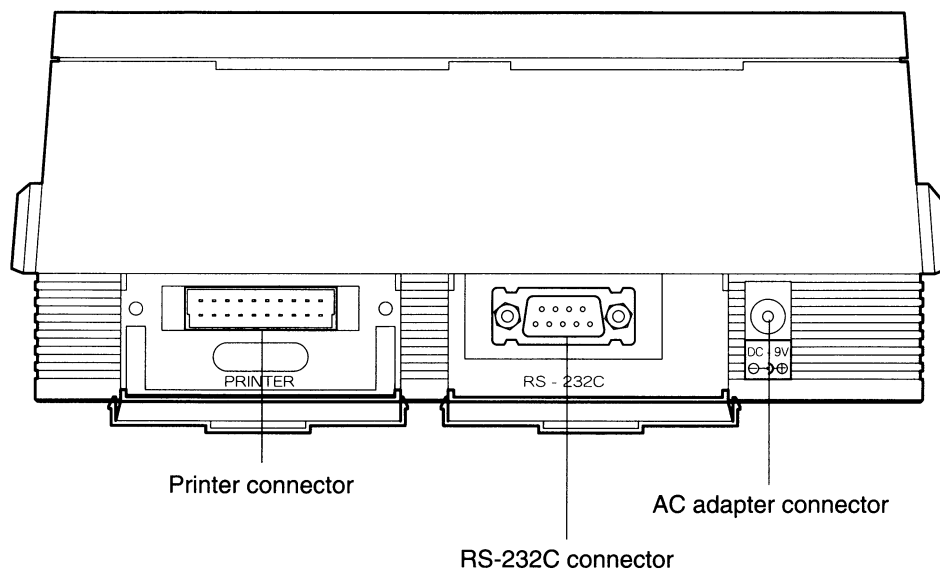
Names of Parts

Main Unit

Front view

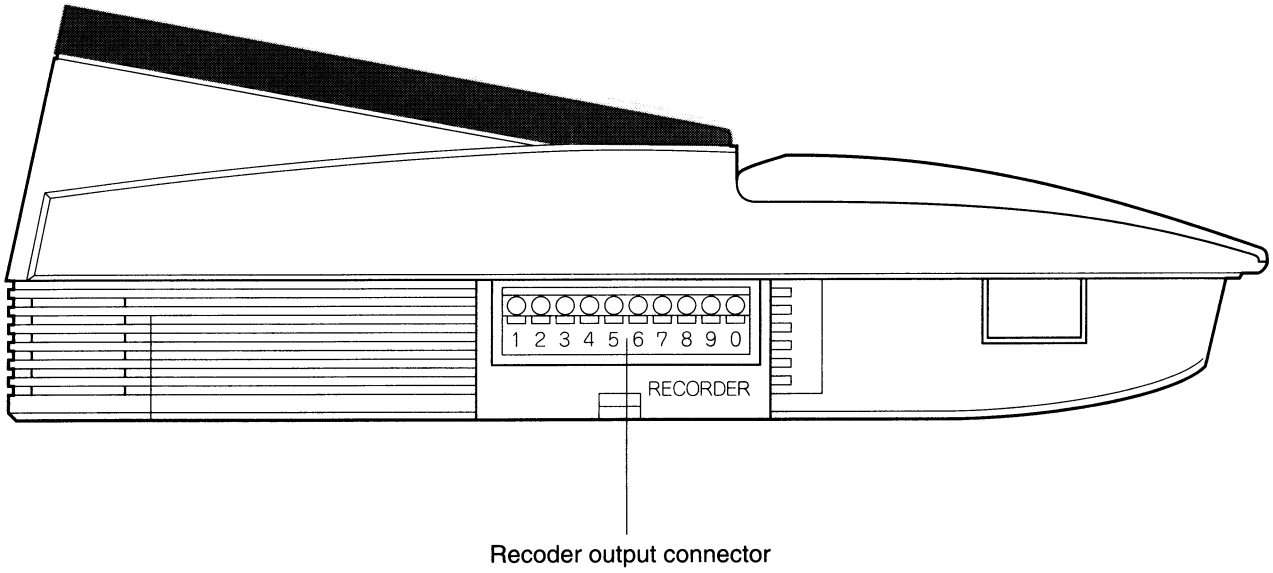


Rear view

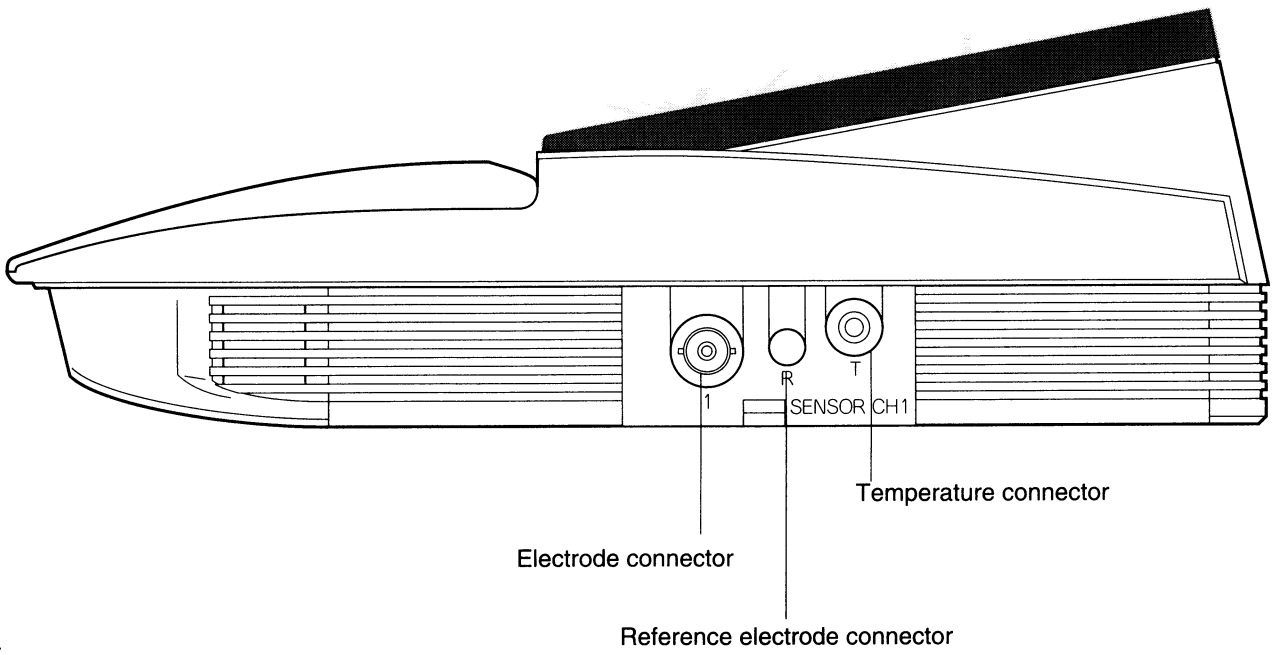


4 *Names of Parts*

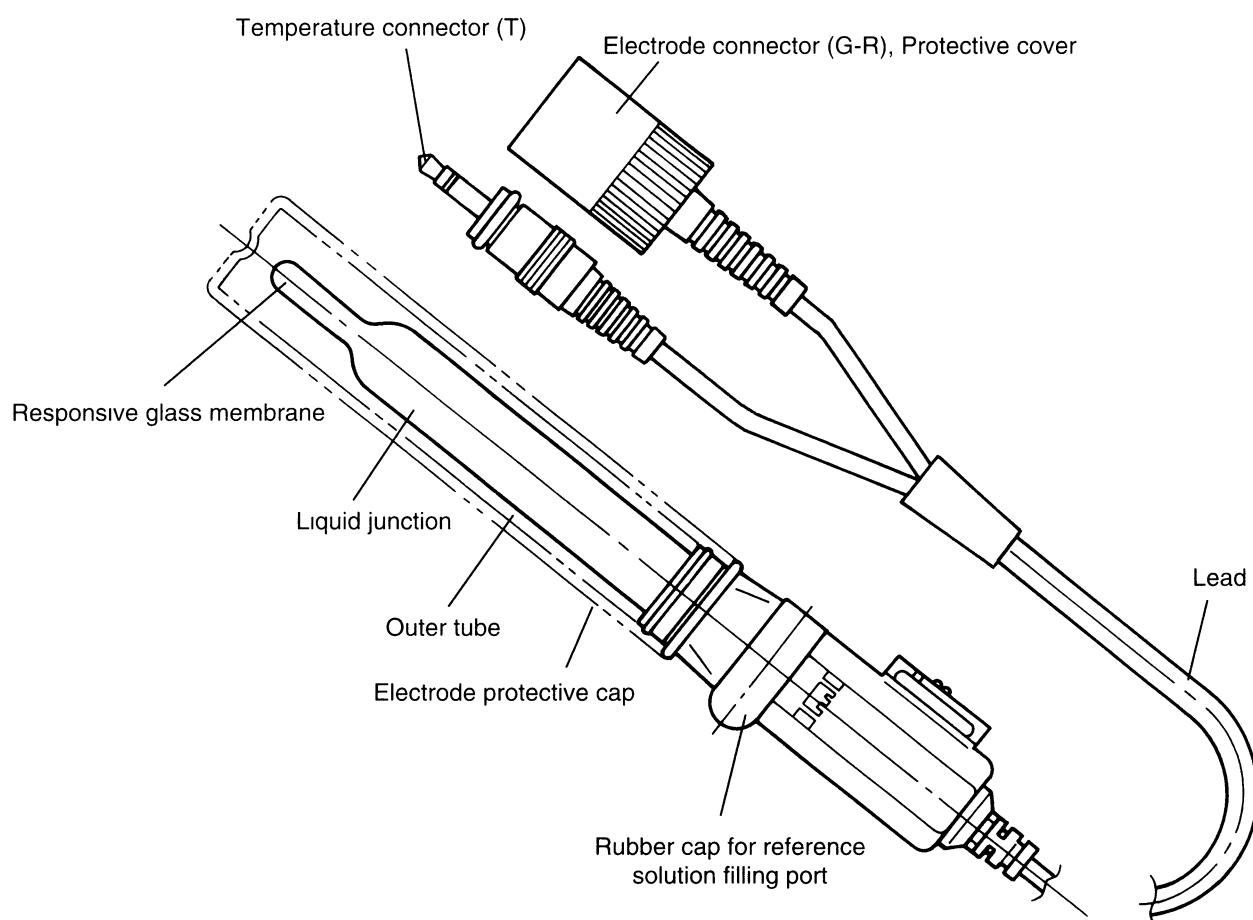
Left side view



Right side view



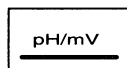
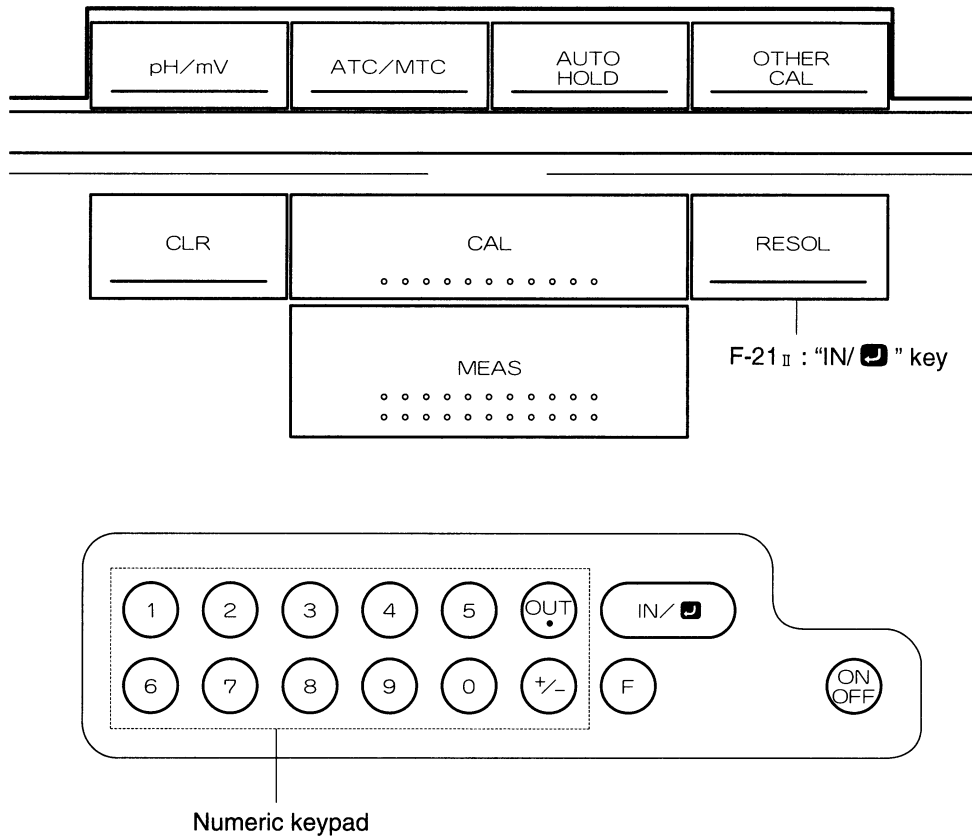
Electrodes



Keys and Display

On the front panel of the pH meter is a set of keys. When a key is pressed and is functional, a single beep will sound. When a key is not accepted, two beeps will sound.

Control Keys



pH/mV key:
Selects whether the measured value is displayed in pH or mV.



ATC/MTC key:
Selects whether temperature compensation for the electrode is provided with the temperature sensor (automatic temperature compensation or ATC) or the specified temperature value (manual temperature compensation or MTC).

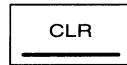


AUTO HOLD key:
Selects whether measurement and calibration are carried out in the AUTO HOLD mode or the MANUAL mode.

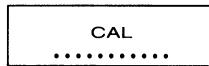


OTHER CAL key:
Starts calibration with any standard buffer other than pH 2, 4, 7, 9*, and 12.

* This becomes 10 for some regions or countries.

**CLR key:**

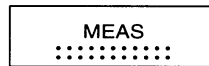
Deletes the calibrated pH values and other stored data. To delete the calibrated pH values, press the **CAL** key with the **CLR** key held down. To delete the stored data, press the **IN/RETURN** key with the **CLR** key held down when that data is displayed in the screen.

**CAL key:**

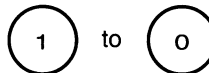
Starts calibrating standard buffers.

**RESOL key: (Not applicable for F-21 II)**

Toggles the number of digits to display the measured value.
pH value: -2.00 to 19.99 ↔ -2.0 to 19.9

**MEAS key:**

Starts measurement.

**Numeric keypad:**

Used to enter the following numeric values:
Temperature for MTC (°C)
pH value of arbitrary standard buffer (pH)
Temperature coefficient of sample (pH/°C)
Time (year, month, day, hour, and minute)
Arbitrary stored data number to call

**OUT key:**

Calls the stored data. Every time this key is pressed, each piece of the data is sequentially called starting with data No. 1.

**IN/RETURN key:**

Reads in the numeric value entered via the numeric keypad. Be sure to press this key after entering a numeric value in each field. This key is also used to store the measured or calibrated value. Allows storing up to 99 data entries. Pressing this key increases the data numbers. If the printer unit is installed, the data is stored and printed.

**+/- key:**

Toggles the positive and negative signs when a temperature coefficient is specified.

**F key:**

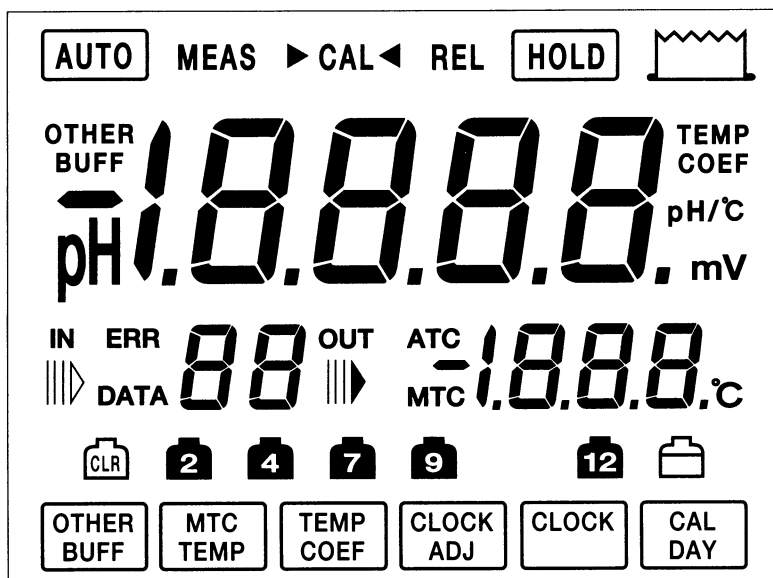
Toggles the special functions.

**ON/OFF key:**

Turns the F-series pH meter on and off.

Reading the Display

The readout shows the temperature and mV value during the measurement. A mark indicates the status of the pH meter as well as the measured pH value.



AUTO

AUTO indication

Shows which mode is selected, the AUTO HOLD mode or the MANUAL mode. When **AUTO indication** is on, you are in the AUTO HOLD mode; when **AUTO indication** is off, you are in the MANUAL mode.

MEAS ▶ CAL ◀

MEASURE&CALIBRATION indication

Shows whether the pH meter is operating for measurement or calibration. When **MEASURE indication** is on, measurement is in progress; when **CALIBRATION indication** is on, calibration is in progress.

REL

REL indication

Lit when the relative mV value is corrected in the mV measurement mode.

HOLD

HOLD indication

When measurement or calibration is carried out in the AUTO HOLD mode, **AUTO indication** blinks until the electric potential has stabilized. When the electric potential has stabilized, **AUTO indication** will stop blinking and then **HOLD indication** will light.



Print Symbol

Lit when the optional printer is connected.

ATC
MTC

ATC&MTC indication

Indicates which is currently selected, ATC or MTC. "MTC" blinks in the screen while you are entering a value for manual temperature compensation.

TEMP
COEF

TEMP COEF indication

Lit when temperature-based conversion is currently enabled. This goes out when a temperature coefficient has been entered.

pH/°C	pH/°C indication Lit when a temperature coefficient (pH/°C) has been entered.
pH	pH indication Lit when a pH value displays.
mV	mV indication Lit when a mV value displays.
OTHER BUFF	OTHER BUFFER indication Blinks when the pH meter is ready to accept the pH value entry of any standard buffer other than pH 2, 4, 7, 9, and 12.

OTHER
BUFF

pH 1.0.0.0.0

TEMP
COEF

pH/°C

mV

Readouts

Displays the following data:
Measured value (pH or mV)
Hour and minute Other buffer value (pH)
Temperature coefficient (pH/°C)

-1.0.0.0.°C

Displays the following data:
Temperature at measurement (°C)
Month and day Temperature specified for manual
temperature compensation (MTC) (°C)

IN
DATA 88

Lit when data is ready to be stored.

DATA 88
OUT

Lit when data is ready to be called.

ERR 88

Lit if an error has occurred.

DATA 88

Blinks when arbitrary stored data will be called.

IN ERR 88 OUT
DATA

Shows the following data:
Year (last two digits) when time is ready to be set.
Second when you have finished setting time or when time is
currently displayed.
Stored data No. Error No. Printed data No.



Identifies the standard buffer used for calibration.



Indicates the calibrated values have been cleared.



Standard buffer of pH 2.



Standard buffer of pH 4.



Standard buffer of pH 7.



Standard buffer of pH 9.









Standard buffer of pH 12.



Standard buffer other than the above

* This becomes 10 for some regions or countries.

	Used to specify the value to calibrate when you are performing calibration with any standard buffer other than pH 2, 4, 7, 9*, and 12.
	Used to specify a temperature for manual temperature compensation.
	Used to specify a temperature coefficient for the sample.
	Used to specify year, month, day, hour, and minute.
	Selects time display.
	Displays the date and time (year, month, day, hour, and minute) of the last calibration.

Memory back-up function

This pH meter uses batteries to back up the calibrated data, the stored data, and the data specified via the numeric keypad. The data is retained even if the pH meter is turned OFF for approximately one year. If the data is lost while the pH meter is turned OFF, the calibrated data and the stored one are cleared and the specified data including time is initialized as follows:

MTC value: 25.0

OTHER BUFF value: 7.000

TEMP COEF value: 0.000

DATA No. 1

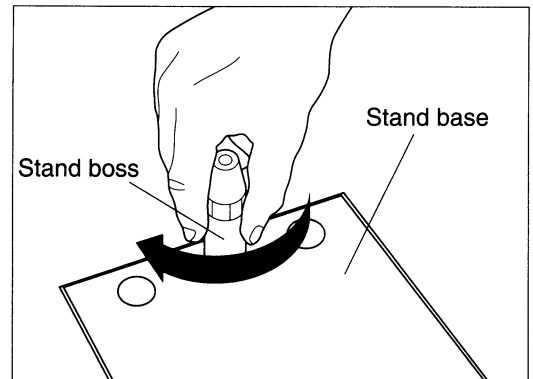
Time: YEAR 93: MONTH 1: DAY 1:

HOUR 0: MINUTE 0: SECOND 1

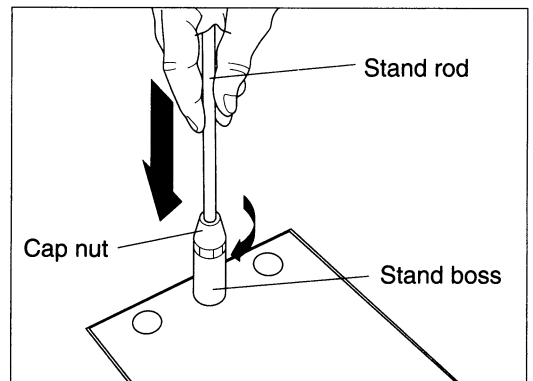
Assembling Electrode Stand

Assemble the electrode stand in the following procedure.

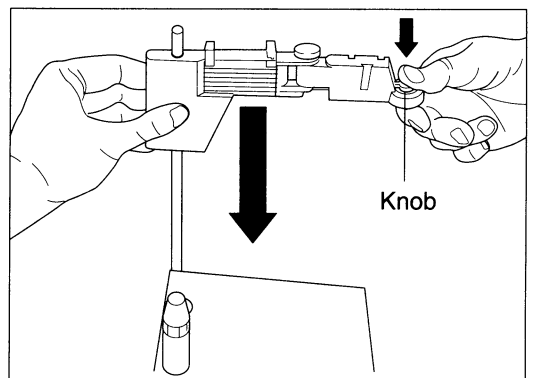
1. Prepare the stand base, stand boss (cap nut), stand rod, and electrode arm.
2. Screw the stand boss into the stand base.



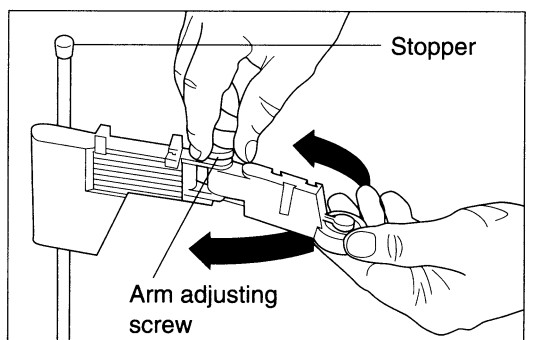
3. Insert the stand rod into the stand boss and tighten the cap nut to retain the rod.



4. Install the electrode arm from the top of the stand rod *while pressing the knob on the arm*. The electrode arm can be adjusted to the desired height by pressing the knob.



5. Use the arm adjusting screw to adjust the horizontal tightness.
6. Put the stopper.



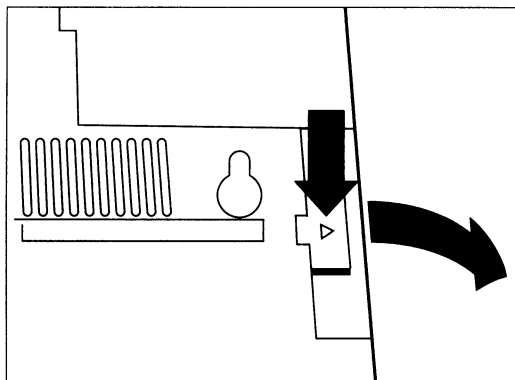
Connecting the Electrode and the Power Source

Connect the F-series pH meter and the electrode in the following procedure:

Note The responsive glass membrane and the highly insulated connectors are liable to damage or failure. Therefore, take care when handling them.

Removing the Connector Lid

1. Remove the connector lid by pulling it while strongly pressing the position marked with black triangle.

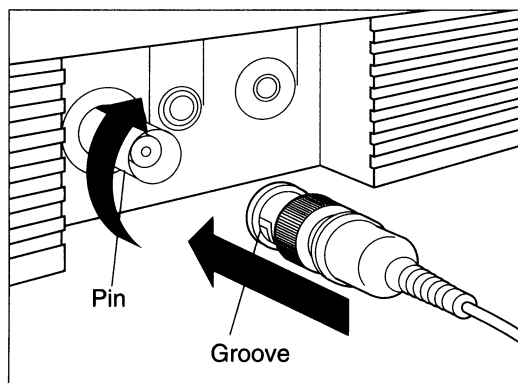


Connecting the Electrode

Note When setting the electrode to the meter, be sure not get any connectors wet, or touch them with dirty hands.

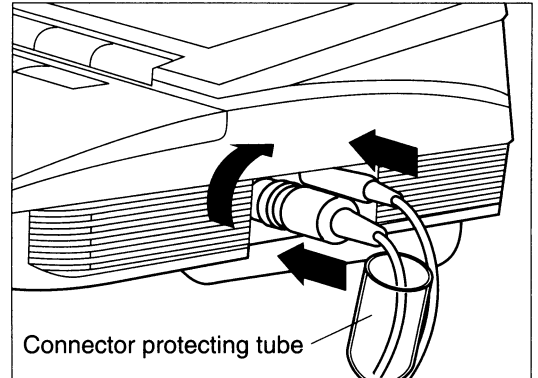
Electrode connector (BNC)

1. Remove the connector protecting tube.
2. Match the slit on the electrode connector with the pin on the counterpart located on the main unit.
3. Turn the electrode connector clockwise to lock it.



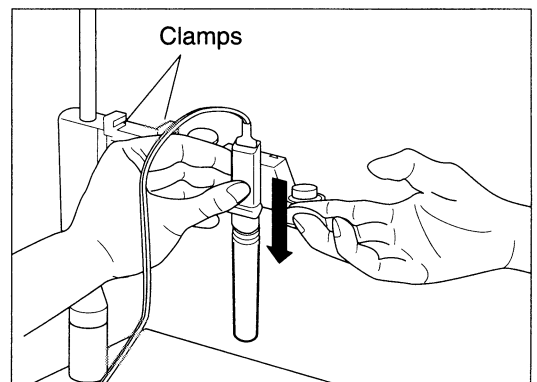
Temperature connector (T)

3. Fully insert the temperature connector into the counterpart located on the main unit.
4. Cover the connector with the connector protecting tube.



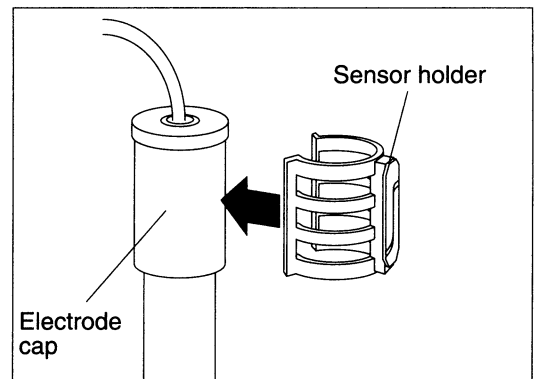
After connecting the electrode connector and the temperature connector to the main unit, install the electrode on the arm and connect the lead wires to the clamps.

Note If measurement is performed in the automatic temperature compensation (ATC) mode without connecting the temperature connector or if the mV measurement is carried out in that state, the temperature reading will be always 25°C.



Snapping the Sensor Holder

To install a certain type of electrode with a cylindrical cap, snap the sensor holder over the electrode cap.

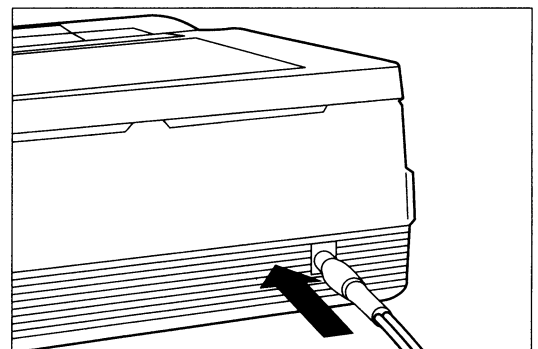


Connecting the Power Source

AC adapter

1. Connect the adapter to the AC adapter connector located on the main unit.

Note Since the F-series pH meter is driven by a DC power source, use the dedicated adapter (AC-10). Properly connect the adapter as shown in the illustration.

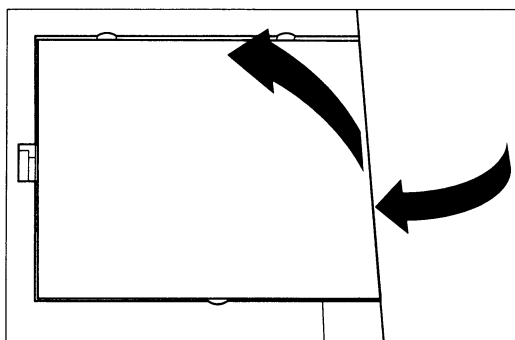


Replacing the Back-up Battery

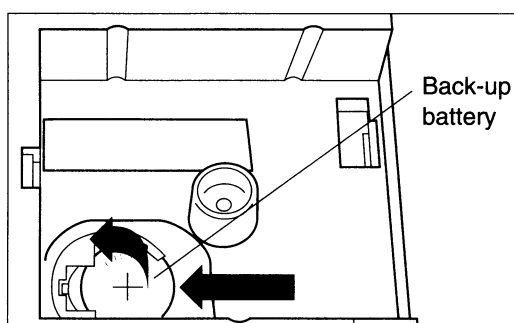
Normally, the calibration data, the memory data, the data specified via the numeric keypad, and other data are retained with the back-up battery. However, when the battery runs out, the data will be lost. If you find that the data is lost when your pH meter is inoperative, replace the battery in the following procedure. (The life of the battery is approximately 1 year though it depends on the operating conditions.)

Note Be sure to use the **ON/OFF** key to turn off the power and disconnect the AC cord.

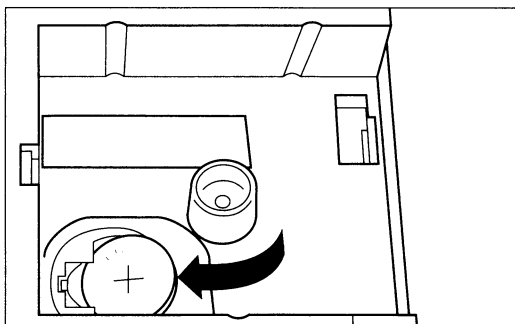
1. Open the rear lid.



2. Push the arrow-marked portion to remove the back-up battery and then replace it.



3. Use the reverse procedure to put the battery in place.



4. Put the rear lid back.

Notes

- When the power is turned on after replacing the battery, ERROR4 will display. In this case, first turn the power off and then on. ERROR4 will disappear. If not, there might be a problem with the pH meter.
- The battery which comes with your pH meter may have shorter life as it is solely intended for demonstration use.

BASIC OPERATIONS

.....

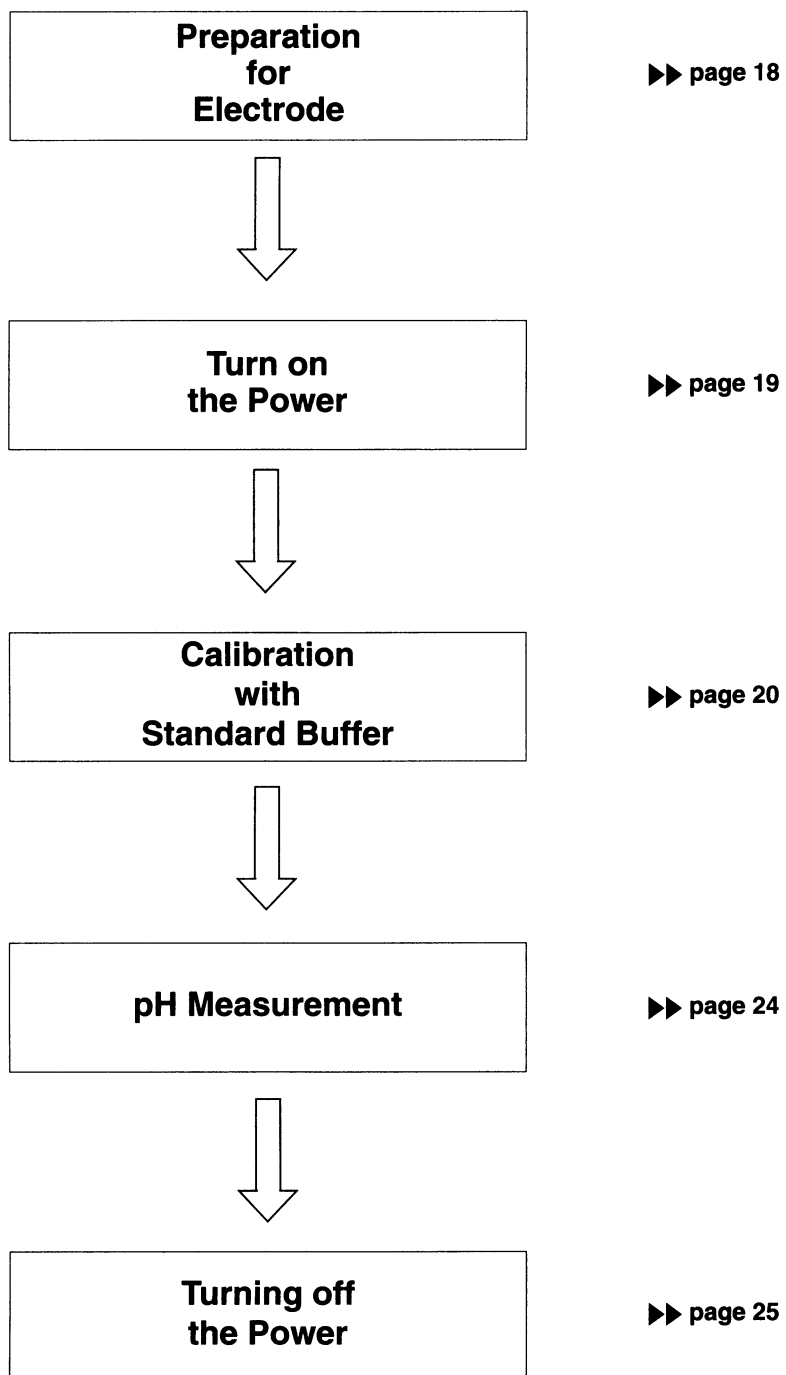
This chapter describes the steps for pH and mV measurements using the F-series pH meter. For those users who use the pH meter for the first time, it is recommended to actually measure a few different samples.

.....

Measurement Flow	16
Operation Flow Diagram	16
Instructions for selecting functions	17
pH calibration	17
pH measurement	17
mV measurement	17
Basic Operations	18
Preparation for Electrode	18
Turn on the Power	19
Calibration with Standard Buffer	20
pH Measurement	24
Turning off the Power	25

Measurement Flow

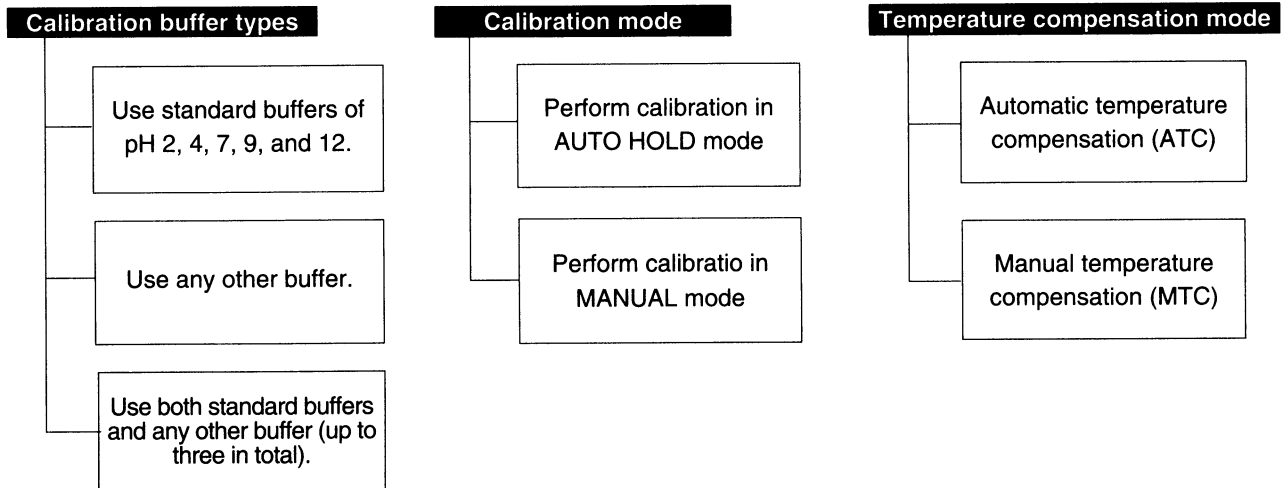
Operation Flow Diagram



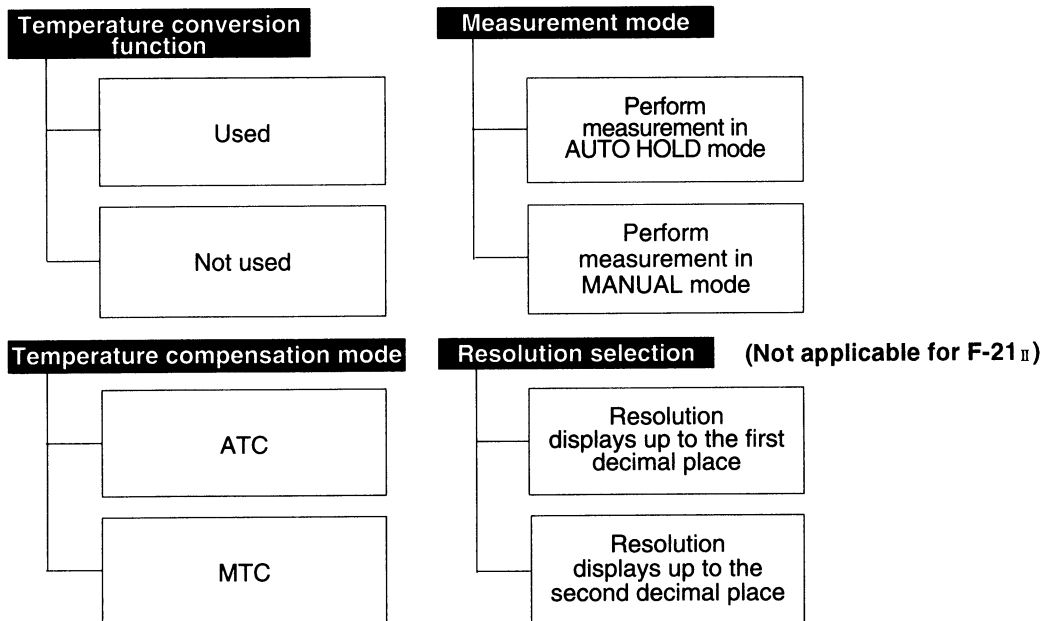
Instructions for selecting functions

This section explains how to select functions for the calibration and measurement operations. For the pH calibration, pH measurement and mV measurement, the following functions are available. For the pH calibration, “kind of buffer,” “calibration mode,” and “temperature compensation mode” can be selected.

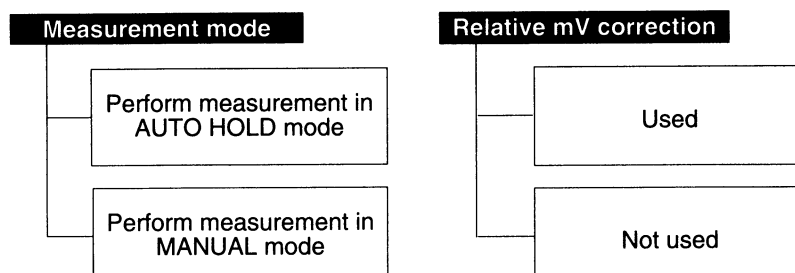
pH calibration



pH measurement



mV measurement



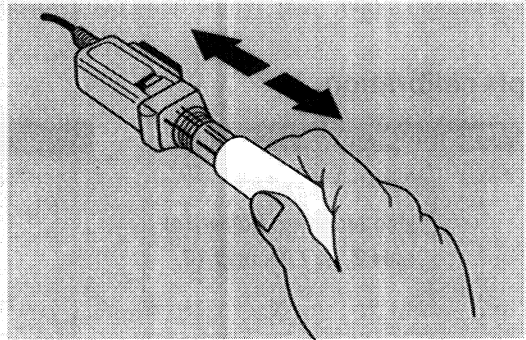
Basic Operations

Preparation for Electrode

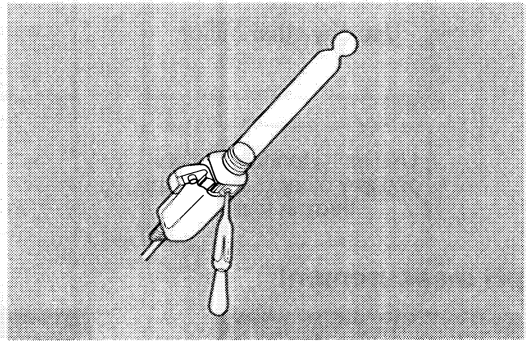
If you use the electrode for the first time, make preparation in the following procedure:

Note If the responsive glass membrane on the tip of the electrode is dried, immerse the tip in deionized water for at least 12 hours before using the pH meter.

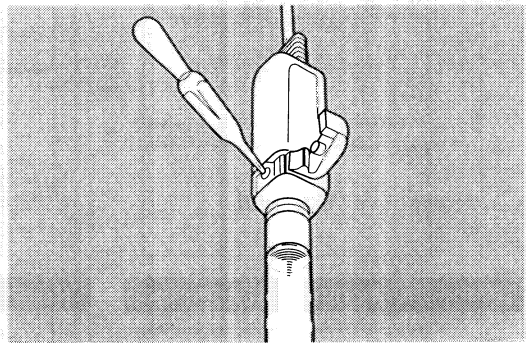
1. Remove the electrode protective cap.



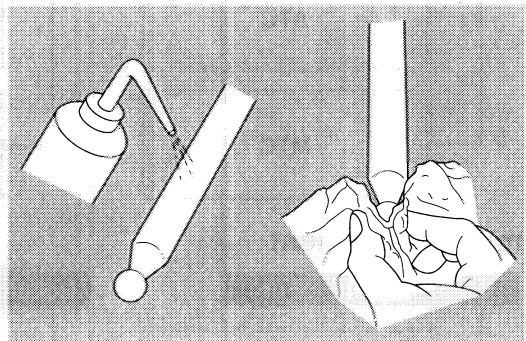
2. Open the rubber cap of the reference solution filling port. Use a filler to suck up the reference solution.




3. Fill the electrode with new reference solution almost up to the rubber stopper level.



4. Wash the tip of the electrode with deionized water or wipe it with filter paper or tissue paper.

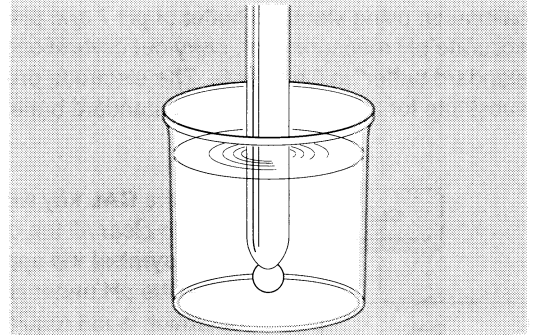


⚠ CAUTION	
	<p>Caution for chemical agent Potassium chloride in high concentration (3.33M KCl) is used for the internal liquid of the electrode. If your hand or skin should be exposed to this chemical agent, immediately wash the hand or skin with water. If diluted hydrochloric acid should splash in your eyes, immediately wash the eye with a large amount of water and then see a doctor for treatment.</p>

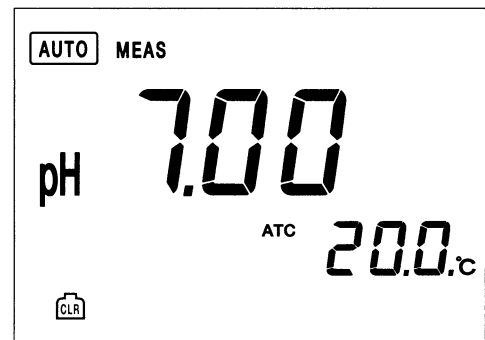
Turn on the Power

1. Immerse the electrode in deionized water.

Note If the pH meter is turned on without immersing the electrode in deionized water, the displayed pH value may fluctuate out of the display range.



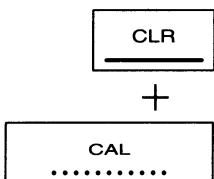
2. Press the **ON/OFF** key.
The screen shown left displays.



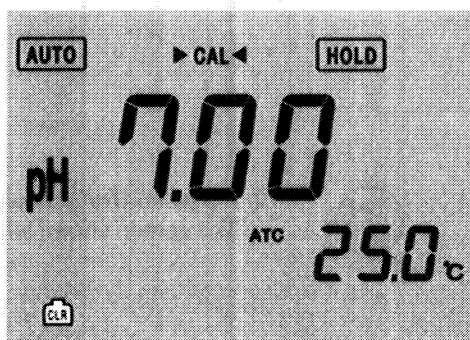
When the pH meter is turned on, it is set as follows:
AUTO HOLD mode: AUTO lights.
Automatic temperature compensation: ATC lights.
pH/mV: pH
Resolution: 0.01 pH

Calibration with Standard Buffer

Be sure to perform calibration before starting measurement. This section describes the operations for two-point calibration using standard buffer of pH 7 and pH 4. For simplified pH measurement, use one-point calibration; for more accurate pH measurement, carry out calibration at more than one point. For the details, refer to the paragraph "Using standard buffer" in Chapter 6. The electrode protective cap which comes with the pH meter may be used as an substitute for a beaker in which a standard buffer is put.

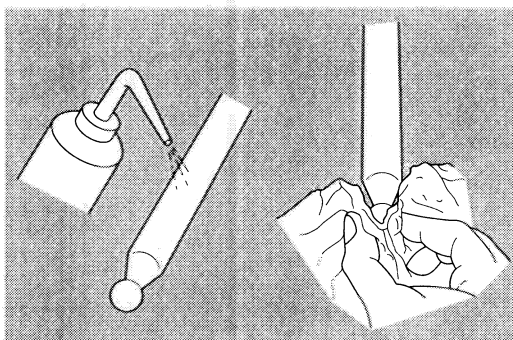


1. Press the **CAL** key with the **CLR** key held down to clear all the calibrated values. The **Clear symbol** will appear. When the pH meter is turned on, this operation is not required because the **Clear symbol** will be shown in the screen.

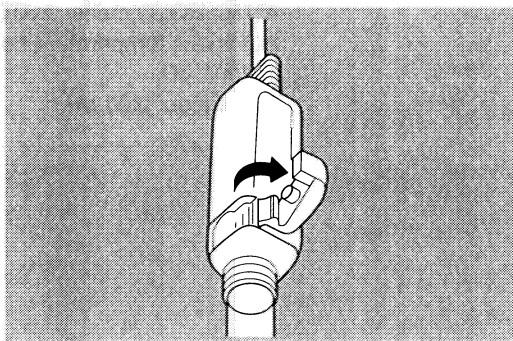


2. Wash the tip of the electrode with deionized water or wipe it with filter paper or tissue paper.

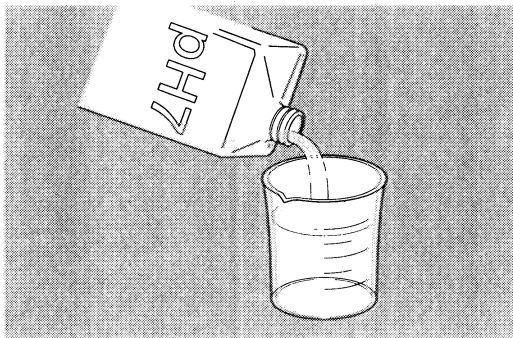
CAUTION	
	<p>Caution for injuries: A broken glass fraction can injure you. The support tube and tip of the electrode are made of glass. Take care that they do not not brake.</p>



3. Open the rubber cap of the reference solution filling port. *This inlet should be left open while calibrations are being carried out.*

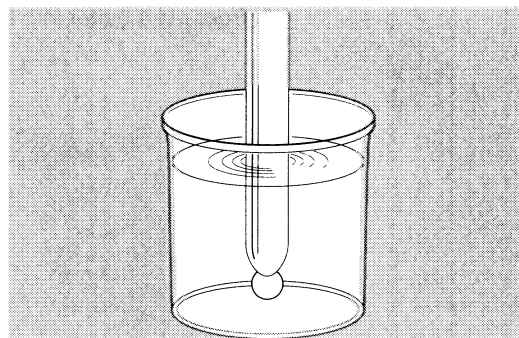


4. Pour pH 7 buffer into the beaker.



5. Immerse the electrode in a beaker.

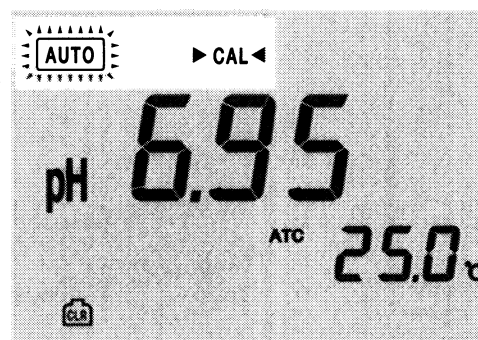
Note If you want to stop the operations after pressing the **CAL** key, press it again.



CAL
.....

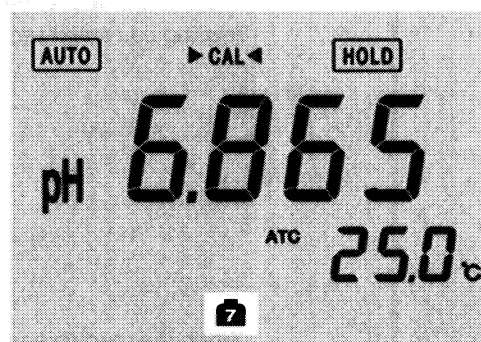
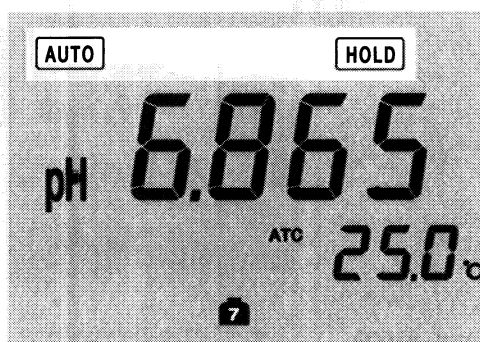
6. Press the **CAL** key.

CALIBRATION indication lights up in the readout and **AUTO** indication blinks until the reading has stabilized.



When the reading has stabilized, **AUTO** indication will stop blinking. The reading is then held with **HOLD** indication lit.

The **pH7** buffer symbol lights up to indicate that the pH meter is calibrated at pH 7.

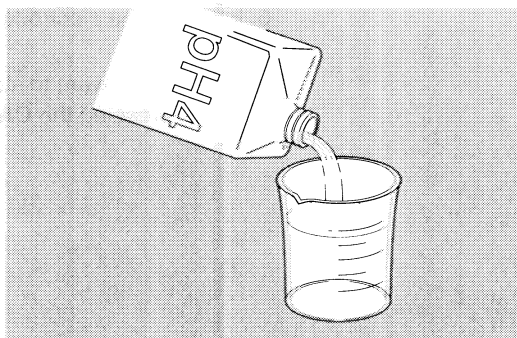


Note The following criteria should be used to determine whether the reading stabilized:
Changes in the difference of electric potentials should fall within the range of ± 1 mV/10 seconds.
Temperature fluctuations should fall within the range of $\pm 2^\circ\text{C}/10$ seconds.
For some regions or countries, pH 7 value is indicated as 7.000 at 25°C

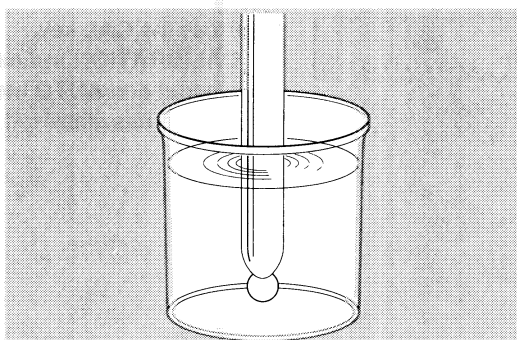
7. The meter is now ready to calibrate using the pH 4 standard buffer. Rinse the electrode including the liquid junction once more in deionized water, then wipe dry with filter paper or tissue paper.

CAUTION	
	<p>Caution for chemical agent Potassium chloride in high concentration (3.33M KCl) is used for the internal liquid of the electrode. If your hand or skin should be exposed to this chemical agent, immediately wash the hand or skin with water. If diluted hydrochloric acid should splash in your eyes, immediately wash the eye with a large amount of water and then see a doctor for treatment.</p>

8. Pour pH 4 buffer into the beaker.

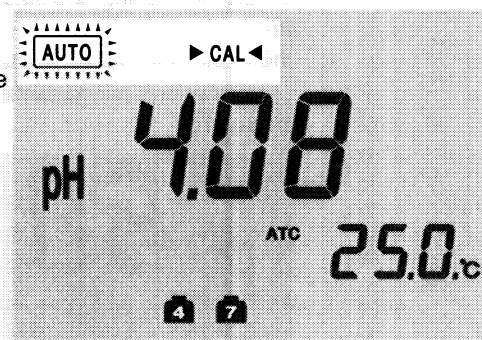


9. Immerse the electrode in a beaker.

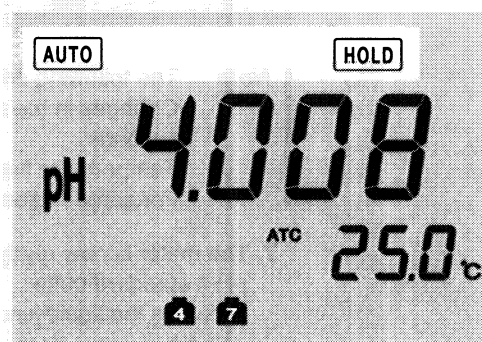


CAL
.....

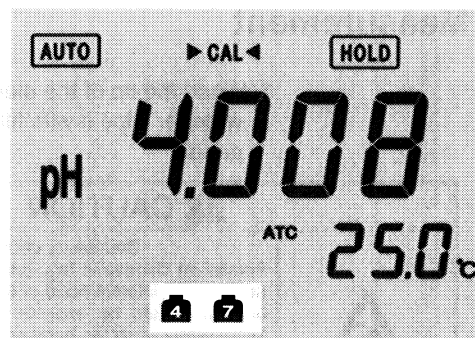
10. Press the **CAL** key.
CALIBRATION indication lights up in the readout and **AUTO indication** blinks until the reading has stabilized.



When the reading has stabilized, **AUTO indication** will stop blinking. The reading is then held with **HOLD indication** lit.



The **pH 4 buffer symbol** lights up to indicate that the pH meter is calibrated at pH 4.




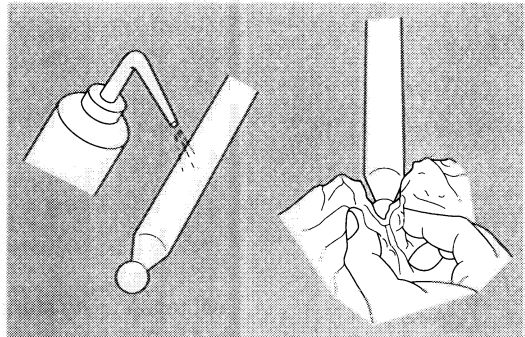
Calibration using standard buffer of pH 7 and pH 4 is now complete. Two **buffer symbols** **pH 4 and pH 7** indicating the standard buffer used will display.

- Notes**
- After calibration completes and the measurement starts by pressing the **MEAS** key, the **CAL** key is never accepted to protect the calibrated values. If you want perform calibration again, first delete the calibrated values and then start calibration.
 - If the second or third calibration cycle is performed again with the previously used standard buffer, the recalibrated latest result is stored in memory.
 - If ERROR7, 8, or 9 appear during calibration, take the appropriate action by referring to the section "Error Numbers" for that error number in Chapter 4 and then start the calibration steps again. These errors show that the electrode is defective. Starting the next calibration or measurement cycle causes the error number to disappear.
 - Calibration cannot be carried out using more than three standard buffers. Calibration using the fourth standard buffers is rejected and ERROR6 will occur. Press the **MEAS** or **CAL** key at the subsequent measurement to clear the error message.
 - For more accurate measurement, immerse 5 to 6 cm from the tip of the pH electrode in the sample.

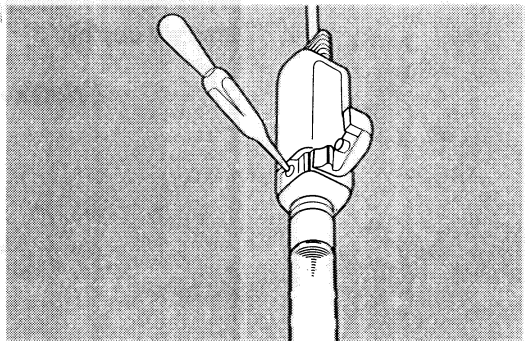
pH Measurement

1. Wash the tip of the electrode with deionized water or wipe it with filter paper or tissue paper.

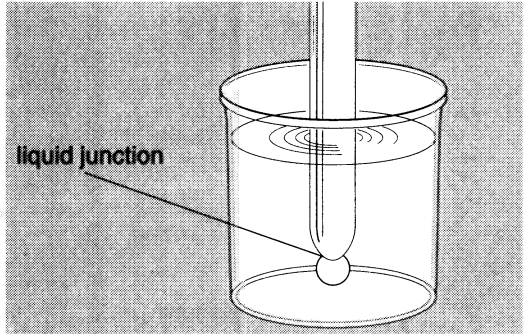
⚠ CAUTION	
	<p>Caution for chemical agent Potassium chloride in high concentration (3.33M KCl) is used for the internal liquid of the electrode. If your hand or skin should be exposed to this chemical agent, immediately wash the hand or skin with water. If diluted hydrochloric acid should splash in your eyes, immediately wash the eye with a large amount of water and then see a doctor for treatment.</p>



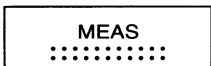
2. Open the rubber cap of the reference solution filling port. This inlet should be left open while calibrations are being carried out.



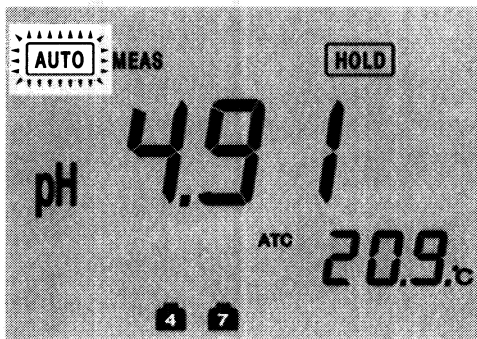
3. Immerse the electrode in the sample completely up to its liquid junction.



Note For more accurate measurement, immerse 5 to 6 cm from the tip of the pH electrode in the sample.



4. Press the **MEAS** key.
The measurement value will display and **AUTO indication** will blink until the reading stabilizes.



Note To abort measurement, press the **MEAS** key again. **AUTO indication** will stop blinking.



When the reading stabilizes, **AUTO indication** will stop blinking. The reading is then held with **HOLD indication** lit.

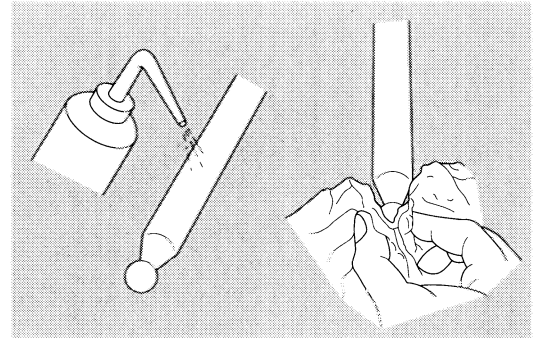
Turning off the Power



1. After measurement, press the **ON/OFF** key to turn off the power.

2. Well rinse the tip of the electrode with deionized water and then wipe it completely. Put the electrode protective cap on the electrode.

 CAUTION	
	<p style="text-align: center;">Caution for chemical agent</p> <p>Potassium chloride in high concentration (3.33M KCl) is used for the internal liquid of the electrode. If your hand or skin should be exposed to this chemical agent, immediately wash the hand or skin with water. If diluted hydrochloric acid should splash in your eyes, immediately wash the eye with a large amount of water and then see a doctor for treatment.</p>



Note For the calibration and measurement described in this chapter, the automatic calibration function is selected. For details on manual temperature compensation, refer to page 33 in Chapter 3.

If the pH meter is not used for a long time, disconnect the AC adapter from the power source.

FUNCTIONS

.....

The F-series pH meter includes a variety of application functions to allow more accurate measurements of pH values. It is recommended to read this chapter while looking at the measurement flow diagram.

Even if these functions are used, measurements are still carried out in the same procedure as described in Chapter 2 Basic Operations. It is recommended to refer to this chapter as appropriate, so that you can make the most of your pH meter.

.....

Calibration and Measurement in the Manual Mode	28
Calibration in the Manual Mode	28
Measurement in the Manual Mode	29
Calibration Using Standard Buffers other than the Specified Ones	31
Specifying the OTHER BUFF mode	31
Calibration using the other buffer	31
mV Measurement Function	32
mV Measurement	32
Measuring the absolute and relative mV values	32
Automatic Temperature Compensation (ATC) and Manual Temperature Compensation (MTC)	33
Setting the MTC	33
Temperature Conversion Function	34
Specifying temperature coefficient and conversion temperature	34
Measurement using temperature-based conversion	35
Clock & Calendar	36
The pH meter has a built-in clock	36
Time display	36
Date and Time of Last Calibration	37
Data Memory Function	38
Storing data	38
Calling data	38
Deleting data	39
Data Output from Recorder	40
Connecting Lead Wires to Recorder Output Terminals	40
Data and its Output Voltage	40

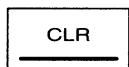
Calibration and Measurement in the Manual Mode

This section describes the manual mode, in which the operator directly reads values when the pH value (electric potential) of the sample fluctuates, for example, at titration.

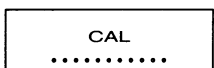
Calibration in the Manual Mode



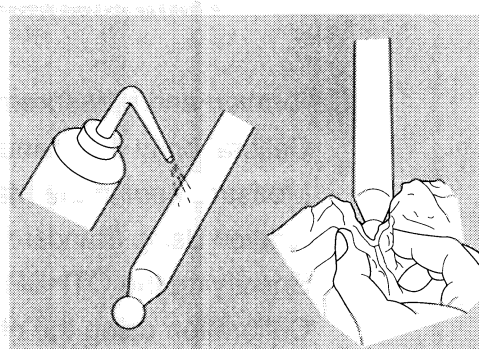
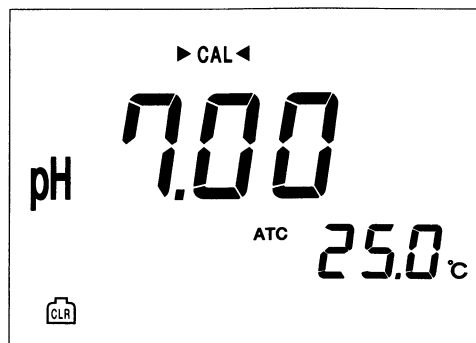
1. Confirm that **AUTO indication** is no longer displayed in the readout. If **AUTO indication** is lit, press the **AUTO HOLD** key (**AUTO indication** goes out) to select the **MANUAL** mode.



2. Press the **CAL** key with the **CLR** key to clear the calibrated values. The **Clear symbol** appears.

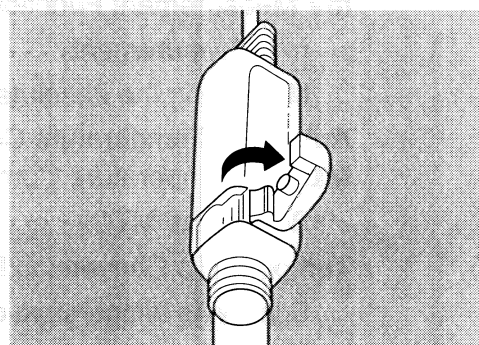


3. Wash the tip of the electrode with deionized water or wipe it with filter paper or tissue paper.

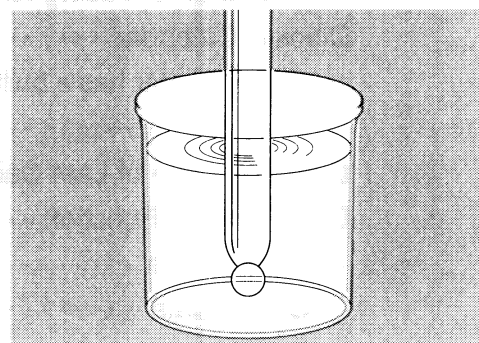


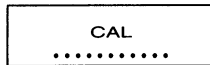
⚠ CAUTION	
	<p>Caution for injuries: A broken glass fraction can injure you. The support tube and tip of the electrode are made of glass. Take care that they do not not brake.</p>

4. Open the rubber cap of the reference solution filling port. This inlet should be left open while calibrations are being carried out.



5. Immerse the electrode in a sample solution.



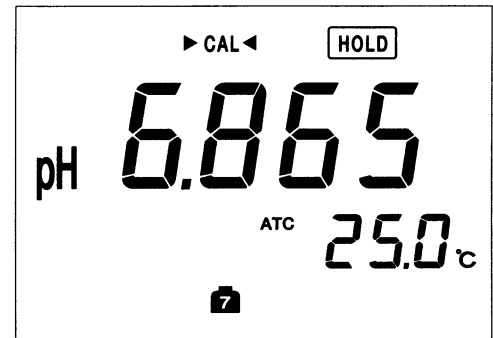


6. Press the **CAL** key.

Note The **CAL** key must be pressed after the reading completely stabilizes.

The bottle marks for the standard buffers used for calibration will display in the screen signalling the calibration is complete. When the **CAL** key is pressed, the reading is held for two seconds.

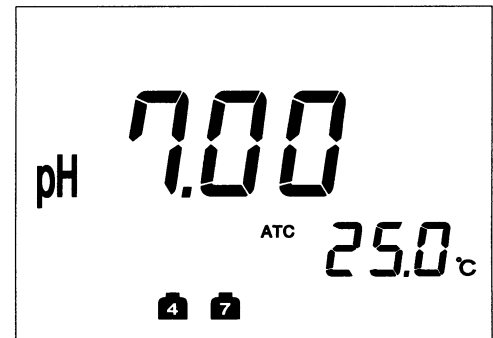
To calibrate the second and third points, carry out the same operations.



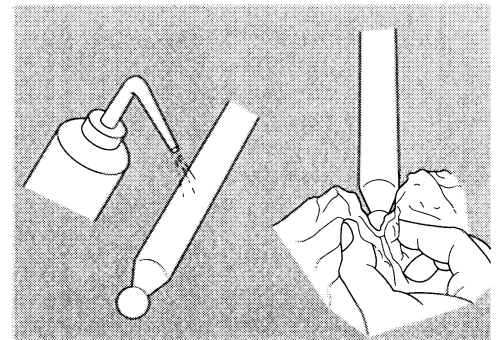
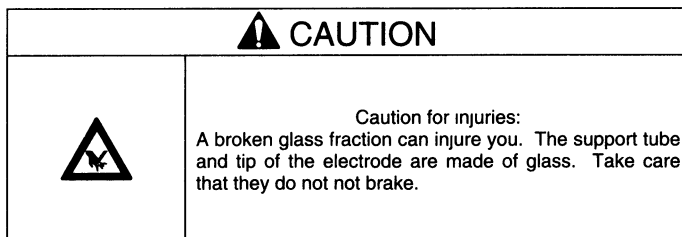
Measurement in the Manual Mode



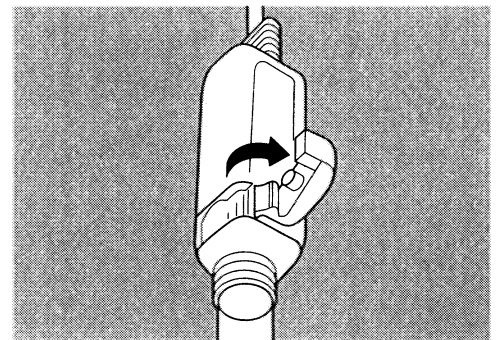
1. Confirm that **AUTO indication** is no longer displayed in the readout. If **AUTO indication** is lit, press the **AUTO HOLD** key (**AUTO indication** goes out) to select the **MANUAL** mode.



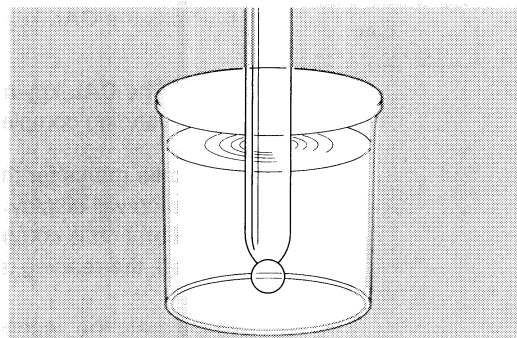
2. Wash the tip of the electrode with deionized water or wipe it with filter paper or tissue paper.



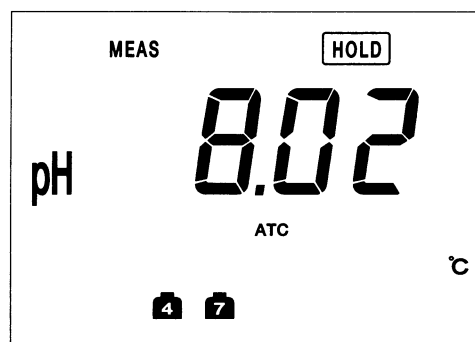
3. Open the rubber cap of the reference solution filling port. This inlet should be left open while calibrations are being carried out.



4. Immerse the electrode in the sample solution.



5. Then read the measured value when the reading has stabilized.
For measurement in the MANUAL mode, when the **MEAS** key is pressed, the momentary value at that time is held for approximately two seconds. This hold automatically cancels and then the measurement is continued.

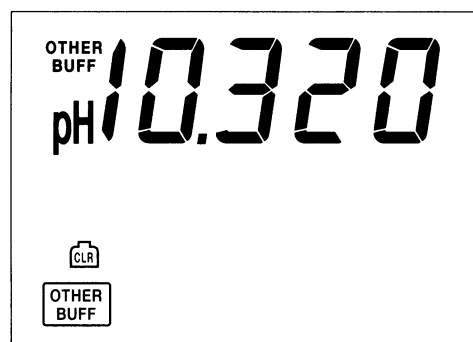
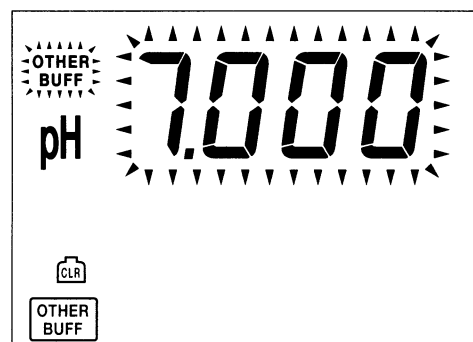


Calibration Using Standard Buffers other than the Specified Ones

This pH meter allows you to use only one arbitrary standard buffer other than the pH 2, 4, 7, 9, and 12. First specify the OTHER BUFF mode and then carry out the calibration operations.

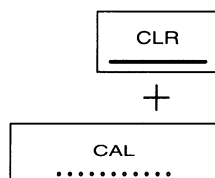
Specifying the OTHER BUFF mode

- Allowable range: pH 0.000 to 14.000
- Press the **F** key to select OTHER BUFF. **OTHER BUFF indication** and the pH value of the currently selected other buffer will appear and then blink in the screen.
- Note** To abort the operation, press the **MEAS** key.
- Use the numeric keypad to enter the pH value of the buffer. It is not necessary to delete the currently displayed pH value. Enter the desired value (the following figure illustrates an example for entering pH 10.32).
- Note** If you have make a mistake in entering the value, press the **CLR** and then enter the value again.
- Press the **IN/RETURN** key. The pH value entered via the numeric keypad is set as the other buffer.
 - Pressing the **MEAS** key will return to the previous screen.



Calibration using the other buffer

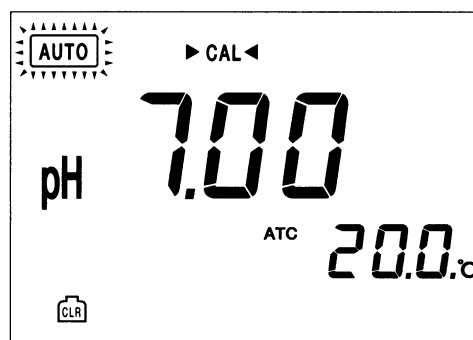
The procedure for this calibration in either the AUTO HOLD mode or the MANUAL mode is the same as that for calibration using the standard buffers of pH 2, 4, 7, 9*, and 12. However, use the **OTHER CAL** key instead of the **CAL** key.



- Press the **CAL** key with the **CLR** key held down to clear the calibrated values. The **Clear symbol** will appear. This operation is not required when the **Clear symbol** is displayed.



- Press the **OTHER CAL** key.



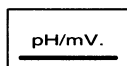
- Notes**
- To abort the calibration in the AUTO HOLD mode, press the **OTHER CAL** key again.
 - Any arbitrary standard buffer can be included in a combination among the standard buffers of pH 2, 4, 7, 9*, and 12 for two-point or three-point calibration.

*This becomes 10 for som regions or countries.

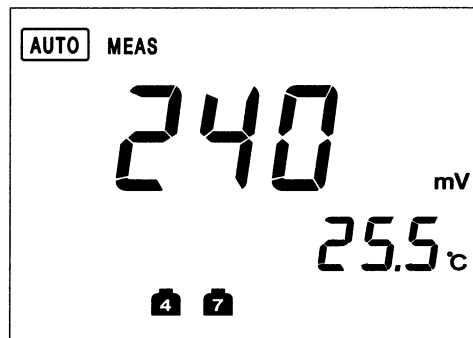
mV Measurement Function

The F-series pH meter allows mV measurements.

mV Measurement

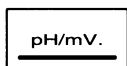


1. Press the **pH/mV** key. **mV indication** will appear in the readout. Pressing the **pH/mV** key again to change **mV indication** to **pH indication**.

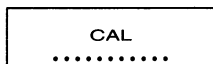


Measuring the absolute and relative mV values

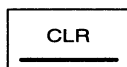
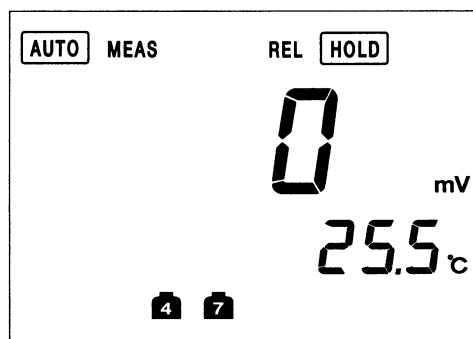
The F-series pH meter allows both the absolute and relative mV measurements. For the former, the measured electric potential is directly displayed; for the latter, offset electric potential is applied to the measured electric potential to force the difference between the two to be output as 0 mV.



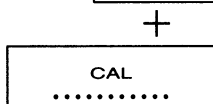
1. Press the pH/mV key so "mV" displays.



2. **Measuring the relative mV value.** Press the **CAL** key. **REL indication** will light. The momentary value at that time is used for correction. After 0 mV is held for approximately two seconds, the momentary relative mV value will display.



3. **Measuring the absolute mV value.** Press the **CAL** key with the **CLR** key held down. The absolute mV value will display.

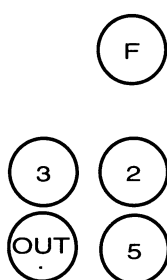


Note The displayed pH value is not influenced by the mV correction.

Automatic Temperature Compensation (ATC) and Manual Temperature Compensation (MTC)

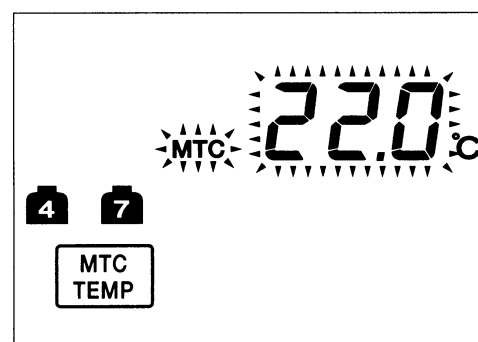
There are two temperature compensation methods available; one is the automatic temperature compensation (ATC) and the other the manual temperature compensation (MTC). For the ATC, the temperature of the solution is sensed by the temperature sensor built in the electrode and then the temperature is compensated. For the MTC, when the temperature sensor is not built in the electrode, the temperature of the solution is previously measured and its value is entered. The temperature is compensated using the entered temperature value.

Setting the MTC



Allowable range: 0.0 to 100.0 (°C)

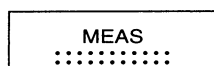
1. Press the **F** key to select "MTC TEMP." **MTC indication** and the currently specified temperature will appear and then blink in the screen.
2. Use the numeric keypad to enter a temperature value. It is not necessary to clear the currently displayed temperature value. Merely enter the desired value. (This figure illustrates an example for specifying 32.5°C.)



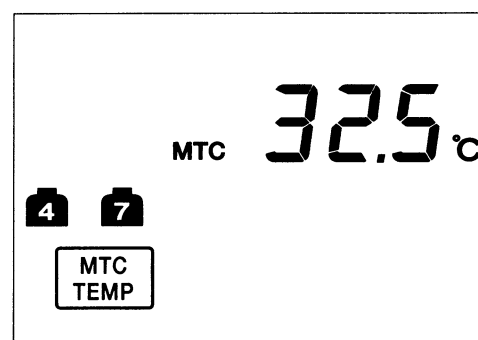
- Notes**
- If you have make a mistake in entering the value, press the **CLR** key and then enter the value again.
 - If a decimal point is entered at the beginning, the value is automatically shown like "0 —."
Example: **OUT/ . + 8 + IN/RETURN** → 0.8
 - If a value is entered with its decimal fraction omitted, zeros are automatically filled.
Example: **32 + IN/RETURN** → 32.0
 - The second decimal place cannot be entered.



3. Press the **IN/RETURN** key. **MTC indication** will stop blinking and then remain lit. The temperature value you entered via the numeric keypad is set as the value for the manual temperature compensation.



4. Press the **MEAS** key to return to the previous screen. At this time, the temperature compensation mode is automatically set to MTC.



Temperature Conversion Function

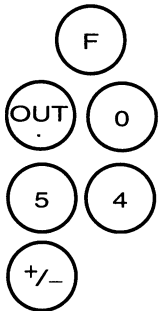
The measured pH value of even the same sample solution varies depending on its temperature. In addition, the degree of temperature changes affecting the pH value differs depending on sample solutions. If this degree (temperature coefficient) is known, the F-series pH meter allows converting the measured pH value into the pH value at the 25°C. This temperature conversion cannot be performed for any sample whose temperature coefficient is unknown.

Specifying temperature coefficient and conversion temperature

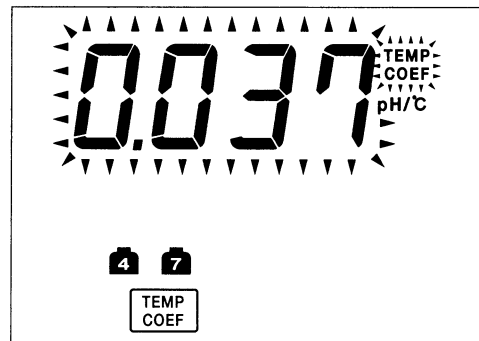
The temperature conversion is made using the following conversion formula:

$$\text{pH}(25) = \text{pH}(t) - \alpha(t - 25)$$
 where: pH (25): pH value converted into a counterpart at 25°C
 pH (t): pH value at 25°C
 α : Temperature coefficient (pH/°C)
 t: Temperature of sample (°C)
 (For the MTC, its specified temperature is "t.")
 Now specify α in the formula. -0.100 to 0.100 (pH/°C)

The following figure illustrates an example for changing the specified value from 0.037 pH/°C to -0.054 pH/°C.



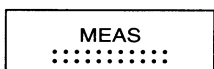
1. Press the **F** key to select "TEMP COEF".
TEMP COEF indication and the currently specified temperature coefficient will appear and then blink in the screen.
2. Use the numeric keypad to enter a temperature coefficient.
It is not necessary to clear the currently displayed temperature coefficient. Merely enter the desired value.



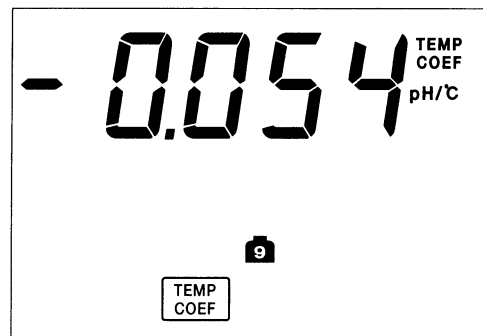
- Notes**
- If you have make a mistake in entering the value, press the **CLR** key and then enter the value again.
 - If a decimal point is entered at the beginning, the value is automatically shown like "0...".
Example: . + 0 + 3 + 8 + **IN/RETURN** → 0.038
 - If a value is entered with its decimal fraction omitted, zeros are automatically filled.
Example: 0 + . + 0 + 4 + **IN/RETURN** → 0.040
 - To cancel the temperature-based conversion function, specify 0.000.



3. Press the **IN/RETURN** key.
The value you entered via the numeric keypad is set as the temperature coefficient.

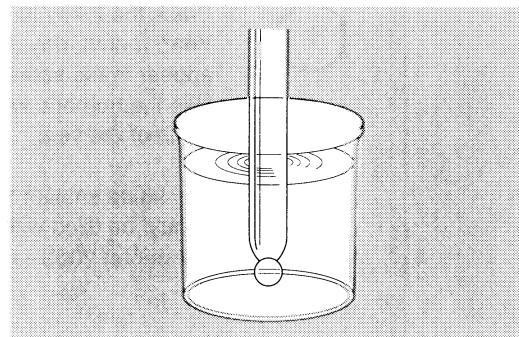


4. Press the **MEAS** key to return to the previous screen.



Measurement using temperature-based conversion

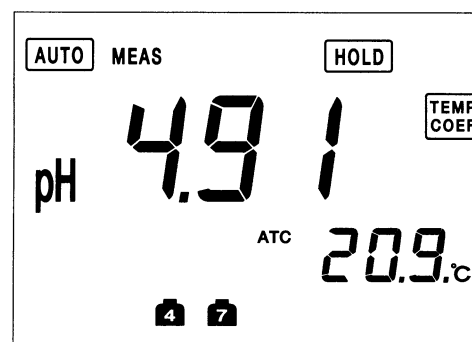
1. After entering a temperature coefficient, immerse the electrode in the sample solution.



MEAS
: : : : : : : : :

2. Then press the **MEAS** key. The measured pH value will be converted to that at 25°C, and then display. When the converted value is currently displayed, **TEMP COEF** indication is lit.

Note When “TEMP COEF” is shown in the screen, the displayed value is the value converted using the temperature coefficient. If temperature-based conversion is not required, specify 0.000.

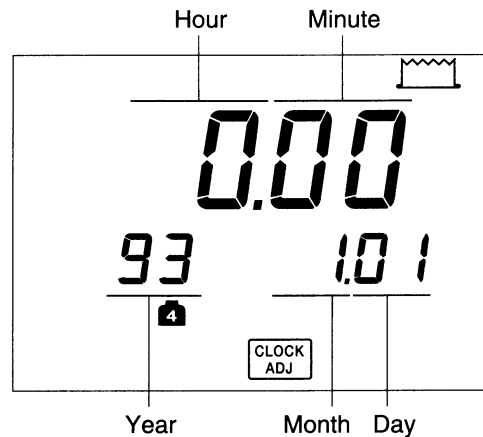


Clock & Calendar

The pH meter has a built-in clock



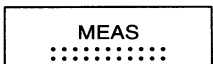
1. Press the **F** key to select "CLOCK ADJ."
Year, month, day, hour, and minute will appear in the screen with the year blinking. Use the numeric keypad to enter the last two digits of the year.
2. Any value smaller than 10 entered for this should be filled with a zero or zeros.
(Example) 2003 → 03



- Notes**
- If you make a mistake in entering the value, press the **IN/RETURN** key to shift the blinking area to the year and then enter the value again.
 - The specified year, month, day hour, and minute data is backed up by the included battery.



3. The blinking area shifts as you enter a value in the year, day, hour, and minute areas. If you do not modify any values, press the **IN/RETURN** key to move to the next area. Use the 24-hour system.
4. After a value is entered in the minute area, the time setting is complete. The two digit year display is changed to seconds and then the time starts.



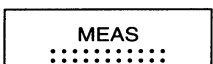
5. Press the **MEAS** key to return to the previous screen.

- Notes**
- For any value smaller than 10, be sure to fill it with a zero or zeros, e.g., 08:06 rather than 8:6.
 - If you try to enter an unreal date or time, it will not be accepted.
 - Leap years are automatically corrected.

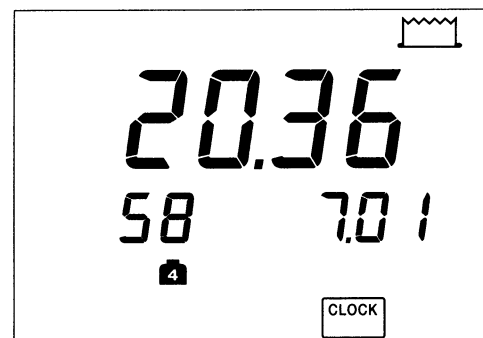
Time display



1. Press the **F** key to select "CLOCK". The time will appear in the screen.



2. Press the **MEAS** key to return to the previous screen.



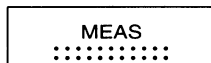
(7.1, 20 : 36 58")

Date and Time of Last Calibration

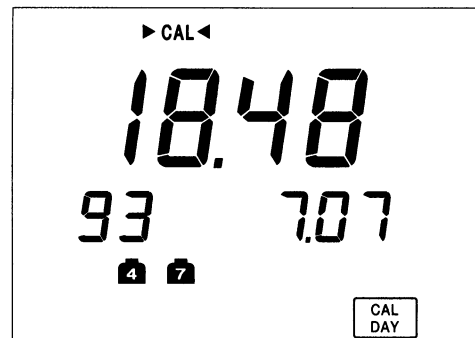
The year, month, day, hour, and minute during the last calibration can be displayed.



1. Press the **F** key to select "CAL DAY." The year, month, day, hour, and minute when the last calibration was carried out will display in the screen.



2. Press the **MEAS** key to return to the previous screen.



(7.7, 1993 18 : 48)

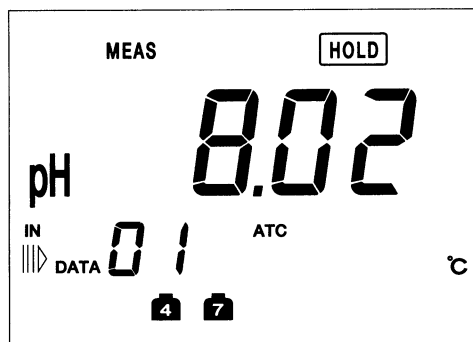
Data Memory Function

Up to 99 data combinations of measured values (pH or mV), temperatures or calibrated pH values and temperatures can be stored and called whenever necessary.

Storing data



1. When the data you want to store is displayed, press the **IN/RETURN** key. The **DATA IN** and its number will appear in the screen and be held for approximately two seconds. This hold automatically cancels and the previous screen will appear.



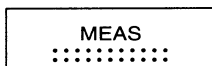
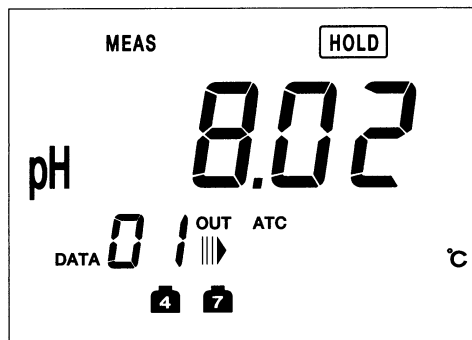
- Notes**
- The data to be stored is numbered starting with 01. Data cannot be stored under an arbitrary number.
 - For data which was converted with a temperature coefficient in the pH mode, **TEMP COEF** indication will light.

Calling data

The stored data can be sequentially called starting with data No. 01 or any desired data No.

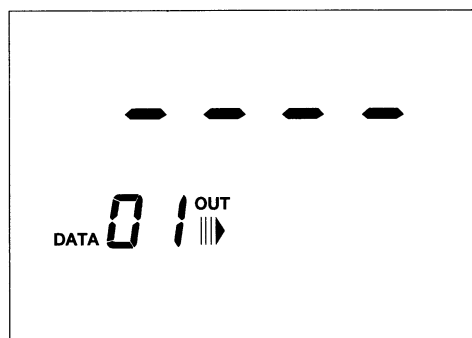


1. Press the **OUT/.** key. **DATA OUT** symbol and data No. 1 will appear in the screen. Every time the **OUT/.** key is pressed, data No. increases by one.
2. To call the desired data No., use the numeric keypad to enter that number. For any one-digit number, enter a zero before that number. (Example) 4 → 04



3. Press the **MEAS** key to return to the previous screen.

Note If there is no data stored, a bar (-) displays in the screen.

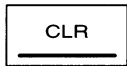


Deleting data

Note This operation clears all the stored data at a time.



1. Obtain data on the screen.



2. Press the **IN/RETURN** key with the **CLR** key held down.

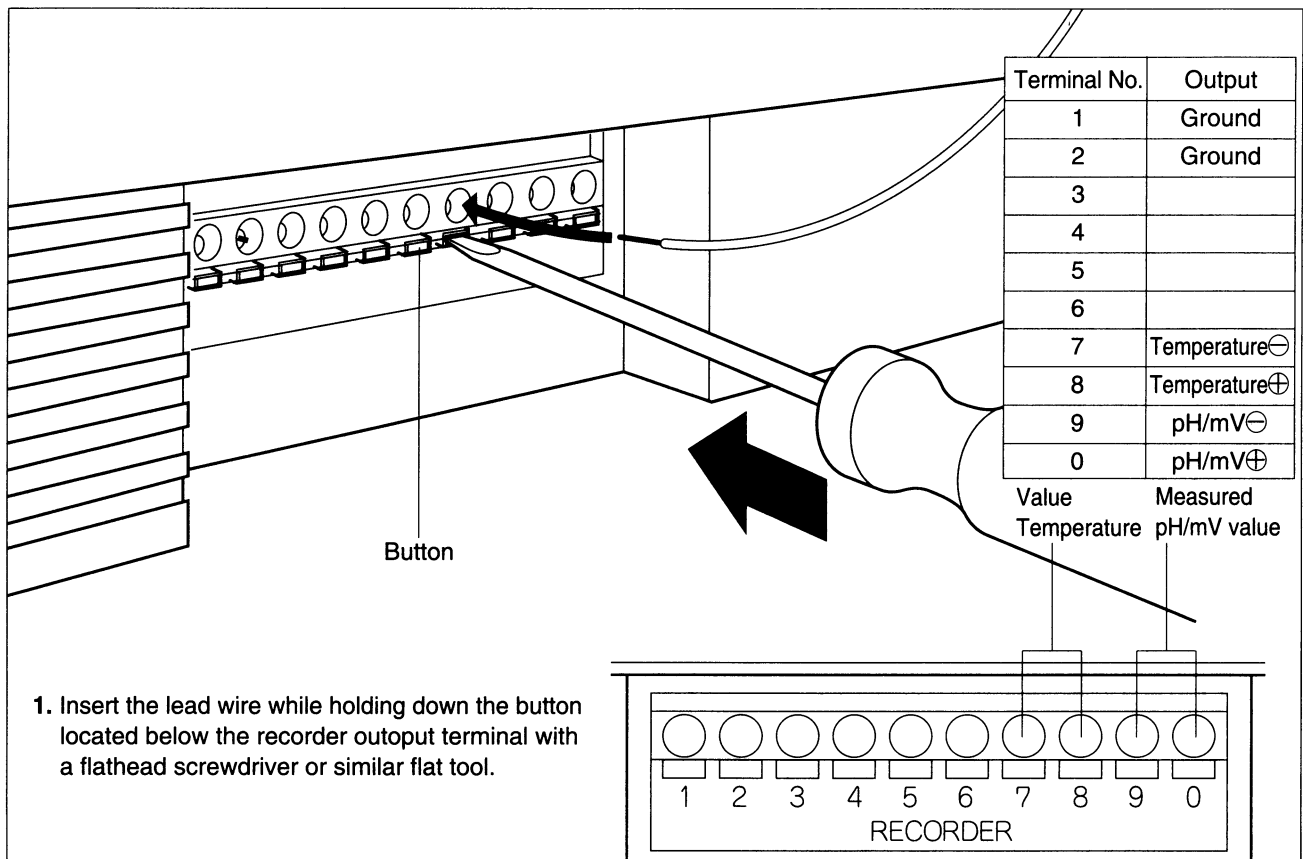
+



Data Output from Recorder

Connecting Lead Wires to Recorder Output Terminals

Two types of data are output as voltage at the recorder output terminals located on the left side of your pH meter. This output can be connected to various analog recorders.



Data and its Output Voltage

The relationship between the data and its output voltage at the initial setting are shown below.

Measured object	Measured value	Output
pH	pH 0 to 14	0 to ± 700 mV (100 mV/1 pH)
mV	0 to ± 1999 mV	0 to ± 1000 mV (100 mV/200 mV)
TEMP	0 to 100 °C	0 to 1.0 V (100 mV/10 °C)

- Notes**
- When the reading is held, the output value is also held.
 - Specifications output cord
 - Solid wire ... 0.4 to 1.2 mm dia. (AWG 26 to 16)
 - Stranded wire ... 0.3 to 1.25 mm² (AWG 22 to 16)
 - Standard stripped wire ... 11 mm length
 - Applicable tool for holding down buttons: Flathead screwdriver (3 mm shaft dia., 2.6 mm slot length)

DAILY MAINTENANCE AND TROUBLESHOOTING

.....

This chapter describes the maintenance of the F-series pH meter and the error messages. In order to ensure accurate measurements and prevent any possible failures from occurring, daily maintenance is important. In particular, not doing maintenance of the electrode will result in problems and errors in the measured value. Since a useful function that displays error messages is available, take an appropriate action whenever an error message displays.

.....

Maintenance of the Electrode	42
Using an Electrode Which Has Not Been Used for a Long Time	42
Storing the Electrode for a Long Time	42
When the Electrode is Very Dirty	43
Error Numbers	44
Error Messages	44
ERROR 3 "ERROR IN MEMORY."	44
ERROR 4 "BAD MEMORY BACK-UP BATTERY."	44
ERROR 5 "AUTO-STD. CANNOT IDENTIFY THIS STD."	45
ERROR 6 "CANNOT STANDARDIZE MORE THAN 3POINTS."	45
ERROR 7 "STABILITY CRITERIA NOT MET."	45
ERROR 8 "EXCESSIVE ASYMMETRY POTENTIAL"	46
ERROR 9 "BAD SENSITIVITY (BELOW 90%)"	46
ERROR 13 "PRINTER MALFUNCTION."	46
Other Troubles	47
No Readout	47
The Reading Fluctuates	47
The Response is Slow	47
The Reading does not Change, nor Respond	47
The measured value blinks (measured pH or mV value)	48
The displayed temperature blinks	48

Maintenance of the Electrode



Using an Electrode Which Has Not Been Used for a Long Time

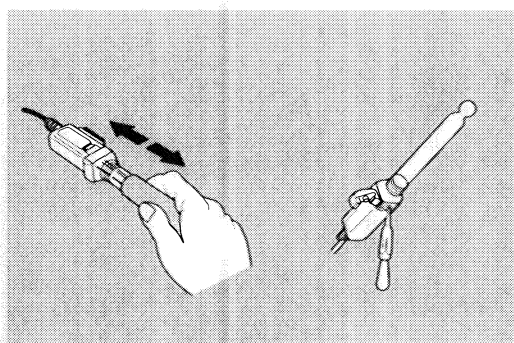
Prepare the electrode as described in the paragraph for preparing the electrode in Chapter 2.

Storing the Electrode for a Long Time

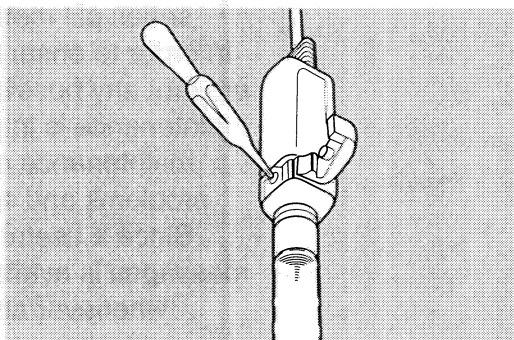
When the electrode is not used for a long period of time, do the maintenance to the electrode in the following steps and then store it. This maintenance should be performed once every three or six months.

1. Remove the electrode protective cap.
2. Open the rubber cap of the reference solution filling port. Use a filler to suck up the reference solution.

 CAUTION	
	<p>Caution for chemical agent Potassium chloride in high concentration (3.33M KCl) is used for the internal liquid of the electrode. If your hand or skin should be exposed to this chemical agent, immediately wash the hand or skin with water. If diluted hydrochloric acid should splash in your eyes, immediately wash the eye with a large amount of water and then see a doctor for treatment.</p>



3. Fill the electrode with new internal liquid up to the level near the rubber stopper.



4. Rinse the tip of the electrode with deionized water and wipe it with tissue paper. If the liquid in the electrode cap is empty, clean the inside of the electrode cap with deionized water, dry it well, and then fill it with deionized water up to the level that the sponge is dipped.



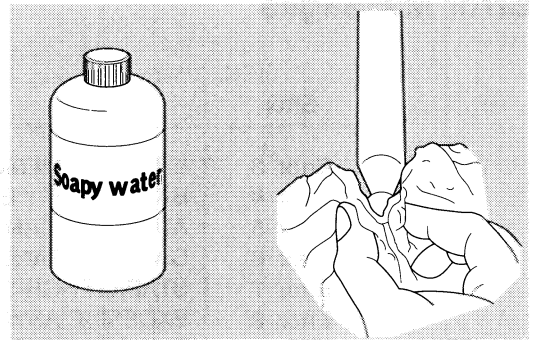
Note If the liquid in the electrode protecting cap is empty, the response of the electrode may be delayed or deteriorate when the electrode has not been used for a long period.

When the Electrode is Very Dirty

Dirt on the tip of the electrode is a major cause of slow response and measurement errors. When the electrode is too dirty to rise with pure water, clean it by the most suitable of the methods given below.

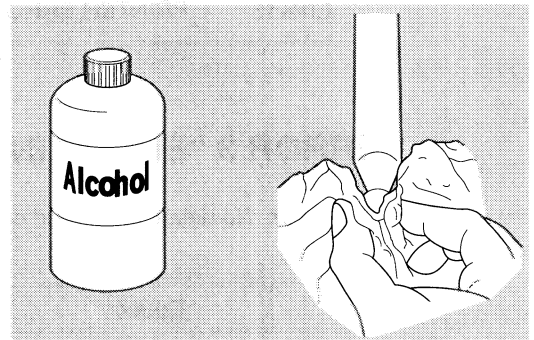
Ordinary dirt

Wipe with gauze or other soft cloth soaked in soapy water.





Oil-related dirt

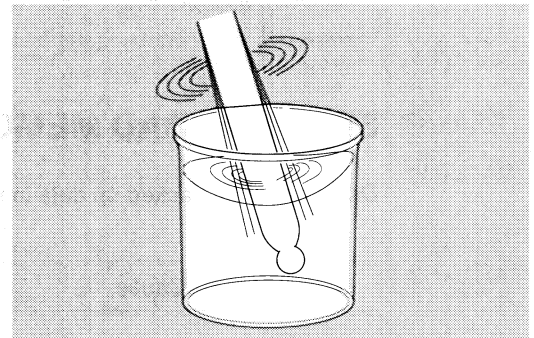
Wipe with gauze or other soft cloth soaked in alcohol.



Dirt containing inorganic substances

 CAUTION	
	<p>Caution for chemical agent Potassium chloride in high concentration (3.33M KCl) is used for the internal liquid of the electrode. If your hand or skin should be exposed to this chemical agent, immediately wash the hand or skin with water. If diluted hydrochloric acid should splash in your eyes, immediately wash the eye with a large amount of water and then see a doctor for treatment.</p>

Clean the electrode in hydrochloric acid of 1 normal concentration. Be sure not to leave the electrode soaking in strong acid. 1 normal concentration of hydrochloric acid: commonly commercially hydrochloric acid diluted to one part in ten.



Error Numbers

The pH meter is equipped with a set of simple error messages to inform the user of operational errors and other problems. These error messages are displayed as error numbers.

Error Messages

Error	Description
Error 3	ERROR IN MEMORY
Error 4	BAD MEMORY BACK-UP BATTERY
Error 5	AUTO-STD.CANNOT IDENTIFY THIS STD.
Error 6	CANNOT STANDARDIZE MORE THAN 3POINTS.
Error 7	STABILITY CRITERIA NOT MET.
Error 8	EXCESSIVE ASYMETRY POTENTIAL.
Error 9	BAD SENSITIVITY
Error13	PRINTER ERROR

ERROR 3 “ERROR IN MEMORY.”

Definition No data can be read or written to the internal memory of the pH meter.

Cause	Action
An internal IC of the pH meter is defective.	Contact our service station for repair.

ERROR 4 “BAD MEMORY BACK-UP BATTERY.”

Definition The backed-up data in memory was lost.

Cause	Action
The voltage of the back-up batteries is low.	Replace the back-up batteries.
No back-up batteries in unit.	Install back-up batteries.

When the power is turned on for the first time after the batteries are replaced, the error message will not clear. This is not abnormal. Turn off the power and then turn it on again. The error message should disappear.

ERROR 5 “AUTO-STD. CANNOT IDENTIFY THIS STD.”

Definition The standard buffer discriminating capability does not work.

Take the action specified below and then try the calibration again.

Cause	Action
The electrode is dirty.	Clean the electrode.
The electrode is cracked.	Replace the electrode.
The standard buffers are bad.	Prepare the standard buffers again.
The concentration of the internal liquid in the comparison electrode changed.	Replace the internal liquid in the comparison electrode.

ERROR 6 “CANNOT STANDARDIZE MORE THAN 3POINTS.”

Definition Calibration was attempted using more than three standard buffers.

Up to three standard buffers can be used for calibration. Refer to page18 Basic operations in Chapter 2. This error will disappear when the next calibration or measurement starts.

ERROR 7 “STABILITY CRITERIA NOT MET.”

Definition After three minutes has elapsed in the AUTO HOLD mode, temperature fluctuation will fail to fall within a range of 1 mV in another 10 seconds.

Take the action specified below and then try the calibration again.

Cause	Action
The electrode is dirty.	Clean the electrode.
The electrode is cracked.	Replace the electrode.
The sample liquid is at low electric conductivity.	The response may be slow; measure the sample liquid in the manual mode.
The responsive glass membrane of the electrode dried for a long period of time.	Immerse the electrode in deionized water for approximately 24 hours and then start measurement.
The temperature of the sample liquid changed.	Start measurement after the temperature of the sample liquid has been stabilized.

Note If ERROR7 occurs with a sample with a particularly low conductivity, such as when deionized water is being measured, contact the factory.

ERROR 8 “EXCESSIVE ASYMMETRY POTENTIAL”

Definition The asymmetric electric potential of the electrode exceeded ± 45.0 mV.

Take the action specified below and then try the calibration again.

Cause	Action
The electrode is dirty.	Clean the electrode.
The electrode is cracked.	Replace the electrode.
The standard buffers are bad.	Prepare the standard buffers again.
The concentration of the KCl internal liquid changed.	Replace the KCl internal liquid.

ERROR 9 “BAD SENSITIVITY (BELOW 90%)”

Definition The actual sensitivity compared to the theoretical one is 90% or less, or 105% or more.

Take the action specified below and then try the calibration again.

Cause	Action
The electrode is dirty.	Clean the electrode.
The electrode is cracked.	Replace the electrode.
Proper calibration is not performed.	Try the calibration again.
The standard buffers are bad.	Prepare the standard buffers again.

ERROR 13 “PRINTER MALFUNCTION.”

Definition An anomaly occurred in the printer.

Turn off the pH meter, take the action specified below, and then turn on the pH meter again.

Cause	Action
The printer paper jammed.	Remove the jammed portion.
The printer unit is not properly connected.	After checking that the printer unit is not properly connected, connect it again.
The printer is abnormal.	Replace the printer.

Other Troubles

This section describes the actions which should be taken for various symptoms that are not identified with error numbers. If you should experience any trouble other than those listed below, contact the factory.

No Readout

Cause	Action
The AC adapter is disconnected.	Firmly connect the AC adapter.
The AC adapter failed.	Replace the AD adapter.

The Reading Fluctuates

Cause	Action
The liquid junction is not immersed in the sample liquid.	Immerse the electrode in the sample complete up to its liquid junction.
The electrode is dirty.	Clean the electrode.
The electrode is cracked.	Replace the electrode.
An external dielectric source such as a motor is located nearby.	Move the pH meter to a place where it is free from the dielectric effect, and then start measurement.

The Response is Slow

Cause	Action
The electrode is dirty.	Clean the electrode.
The electrode is cracked.	Replace the electrode.

The Reading does not Change, nor Respond

Cause	Action
The reading is held.	Cancel the HOLD mode.
The electrode is cracked.	Replace the electrode.
The electrode connector is not properly connected.	Properly connect the electrode connector.
The pH meter is abnormal.	Contact the factory for repair.
The program runs away.	First turn OFF the pH meter and then turn it on. If the problem still exists, contact the factory.

The measured value blinks (measured pH or mV value)

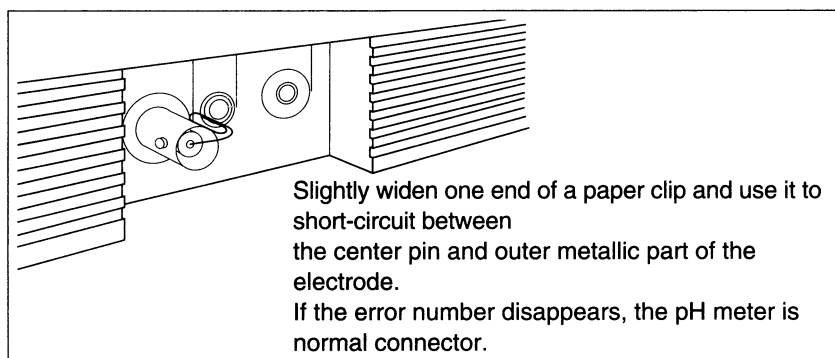
The pH value exceeds the display range. (in the pH mode)

Measurable range: pH 0.00 to 14.00

The mV value exceeds the display range. (in the mV mode)

Measurable range: ± 1600 mV

Cause	Action
The sample solution is not correct.	Replace it with a sample whose pH value falls within the measurable range.
The liquid junction is not immersed in the sample liquid.	Immerse the electrode in the sample complete up to its liquid junction.
The electrode connector is not properly connected.	Properly connect the electrode connector.
The electrode cable is broken.	If broken, replace the electrode.
The pH meter might be abnormal.	Check whether the pH meter is abnormal or not by shorting the electrode connector as shown in the following figure.



The displayed temperature blinks

The temperature exceeds the display range. Measurable range: 0.0 to 100.0°C

Cause	Action
The temperature of the sample exceeds the measurable range.	Check the temperature of the sample solution.
The thermistor in the electrode is broken or short-circuited.	If broken, replace the electrode.
The electrode connector is abnormal.	Replace the electrode.

RS-232C INTERFACE

Points to Check Before Use	50
RS-232C Related Commands	51
Operation Commands	51
Data Specifying Commands	51
Data requesting commands	51
On-Line Operation Commands	52
On-line/Off-line	52
Abort Electric Potential Tracing	53
Specifies pH Mode	53
Specifies mV Mode	53
Starts Measurement	54
Starts pH Calibration Using Standard Buffers	54
Starts pH Calibration Using Other Buffers	54
Cancels Calibration	54
Command to Specify Data	55
Specifies AUTO HOLD	55
Specifies pH Temperature Compensation	55
Specifies pH Resolution	56
Specifies pH Temperature Conversion	56
Specifies Time Data	56
Command to Request Data and Response from pH Meter	57
Requests pH Calibration Date and Response	57
Requests pH Other Buffer Calibration Value and Response	58
Requests the Specified pH Temperature Compensation Value and Response	59
Requests the pH Temperature Conversion Value and Response	59
Requests the Measured Value and Response	60
Requests Time Data and Response	61
Sample Program	62
Connecting the F-21 Series to a Personal Computer	62
Sample program	62
Flow chart of sample program	63
Sample Program	64
Modifying the Program	65
Considerations To Be Noted in a Modification	65
RS-232C Specifications	66

Points to Check Before Use

Before using the RS-232C port, pay attention to the following points:

Be sure the transfer format of the pH meter matches that of the computer.
The transfer settings are shown below:

Baud Rate : 2400 bps
Word Length : 8 bits
Parity : None
Stop Bits : 1 bit

If the transfer format is different, a communication error will occur or the on-line mode will not start preventing normal communication via the RS-232C port. If the transfer format is changed, first turn off the pH meter and the computer and then turn them both on again.

To create a program related to the RS-232C port, use the on-line command at the beginning of the program to put the pH meter in the on-line mode. When the pH meter is put in the on-line mode, the control switches are invalid and the RS-232C communication mode is enabled. Turning off the pH meter cancels the on-line mode.

If no received data is sent out when a data request is issued, rewrite the program so that the data request issues again after a short time. This ensures more reliable communication.

The input and output of data in the command format has zero suppression for the read.

When the RS-232C communication is not used, put the protective cover on the RS-232C connector.

RS-232C Related Commands

Operation Commands

Description			Command		Page reference
			Header	Code	
On-line operation	1	On-line/Off-line	C	OL	52
	2	Aborts Electric Potential Tracing		BR	53
	3	Specifies pH Mode		PH	53
	4	Specifies mV Mode		MV	53
	5	Starts Measurement		MS	54
	6	Starts pH Calibration Using Standard Buffers		CP	54
	7	Starts pH Calibration Using Other Buffers		CO	54
	8	Cancels Calibration		CC	54

Data Specifying Commands

Description			Command		Page reference
			Header	Code	
Data specification	1	Specifies AUTO HOLD	S	AH	55
	2	Specifies pH Temperature Compensation		PI	55
	3	Specifies pH Resolution		PB	56
	4	Specifies pH Temperature Conversion		PT	56
	5	Specifies Time Data		OT	56

Data requesting commands

Description			Command		Page reference
			Header	Code	
Data request	1	Requests pH Calibration Date	R	PC	57
	2	Requests pH Other Buffer Calibration Value and Response		PO	58
	3	Requests the Specified pH Temperature Compensation Value and Response		PI	59
	4	Requests the pH Temperature Conversion Value and Response		PT	59
	5	Requests Measured Value and Response		MD	60
	6	Requests Time Data and Response		OT	61

On-Line Operation Commands

Commands to control the operation of the pH meter.

The pH meter can be controlled by the computer using the following eight commands for on-line operations.

- On-line/Off line
- Aborts Electric Potential Tracing
- Specifies pH Mode
- Specifies mV Mode
- Starts Measurement
- Starts pH Calibration Using Standard Buffers
- Starts pH Calibration Using Other Buffers
- Cancels Calibration

The commands which can be executed by the computer are listed later. When a command has been accepted by the pH meter, the following response is returned by the pH meter:

a. When a command has been accepted, OK is sent.

OK **CR** **LF**

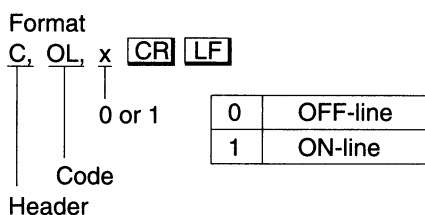
b. When a command has been rejected:

ER, n **CR** **LF**

- n = 0 : Communication error
- 1 : Condition code cannot be found
- 2 : Wrong operation
- 3 : Data out of allowable range

CR	: Carriage return
LF	: Line feed
	: Space

On-line/Off-line



Selecting On-line/Off-line

OFF → ON	The pH meter will be placed in the state (OK) in which it has accepted a command. The pH meter will not accept a command in the BUSY mode (measurement or calibration in the AUTO HOLD mode). ERROR2 CR LF (wrong operation) are output.
ON → OFF	The pH meter is put in the same state as when it is turned on.

Abort Electric Potential Tracing

Format

C, BR CR LF
 | |
 | Code
 Header

Note This command is only valid when on-line measurement or calibration is in progress in AUTO HOLD mode. The measurement or calibration in AUTO HOLD is aborted. For a calibration in progress, the calibration calculation is not performed. However, if AUTO HOLD is set to OFF, an error will still be returned during measurement.

Specifies pH Mode

Format

C, PH CR LF
 | |
 | Code
 Header

Note This command is always valid in the on-line mode. The pH meter is put in the pH READY mode or the CALIBRATION READY mode.

Specifies mV Mode

Format

C, MV CR LF
 | |
 | Code
 Header

Note This command is always valid in the on line mode. The pH meter is put in the mV READY mode.

Starts Measurement

Format
 C, MS CR LF
 | |
 | Code
 Header

Note This command is valid in the on-line READY mode. Measurement starts on the channel which is in the current mode.

Starts pH Calibration Using Standard Buffers

Format
 C, CP CR LF
 | |
 | Code
 Header

Note This command is valid in the on-line pH READY or CALIBRATION READY mode. pH standard calibration starts.

Starts pH Calibration Using Other Buffers

Format
 C, CO xx, xxx CR LF
 | | |
 | | Value to specify for other buffers: 6
 | Code digits including decimal point (up to 3
 Header decimal places); 0.000 to 14.000

Note This command is valid in the on-line pH READY mode or CALIBRATION READY mode. pH calibration using other buffers starts.

Cancels Calibration

Format
 C, CC CR LF
 | |
 | Code
 Header

Note This command is valid in the on-line pH READY mode or CALIBRATION READY mode. The pH calibration value using standard buffers and that using other buffers are cleared.

Command to Specify Data

Data can be specified for the pH meter by the computer using the following five commands for specifying data:

- Species AUTO HOLD
- Species pH Temperature Compensation
- Species Resolution
- Species pH Temperature Compensation
- Species Time Data

The commands which can be executed by the computer are listed later. When a command has been accepted by the pH meter, the following response is returned by the pH meter:

a. When a command has been accepted, OK is sent.

OK **CR** **LF**

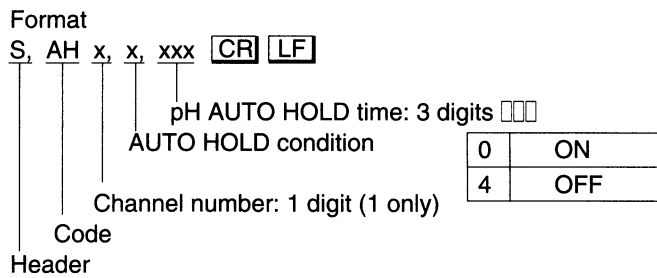
b. When a command has been rejected:

ER, n **CR** **LF**

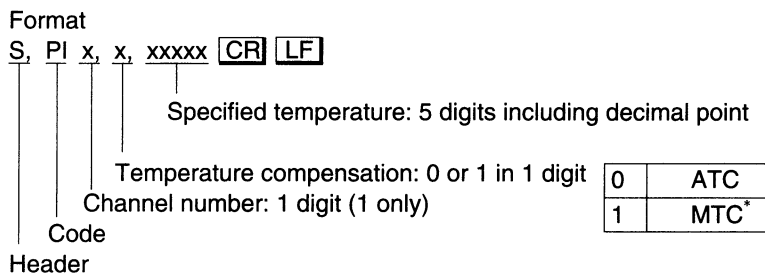
- n = 0: Communication error
- 1: Condition code cannot be found
- 2: Wrong operation
- 3: Data out of allowable range

CR	: Carriage return
LF	: Line feed
	: Space

Specifies AUTO HOLD

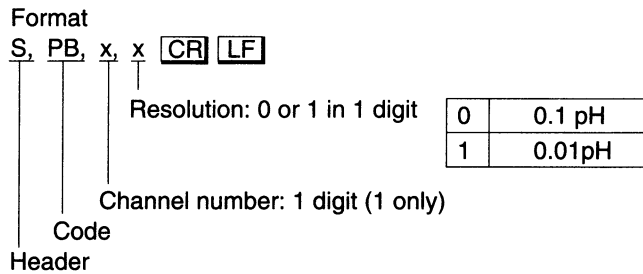


Specifies pH Temperature Compensation

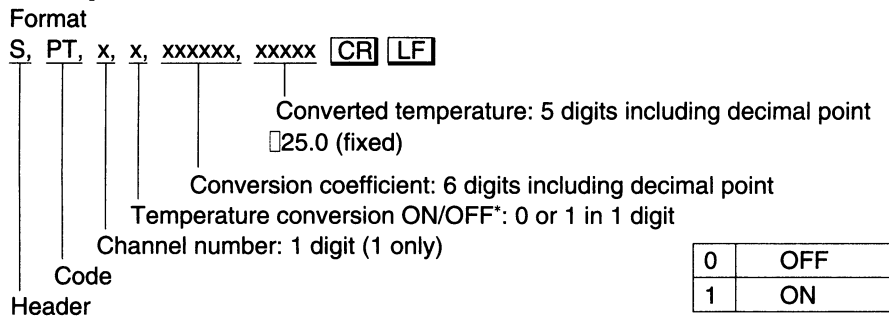


*When pH temperature compensation is set to:
 "0: ATC";
 "1: MTC"; 0.0 to 100.0

Specifies pH Resolution (Not applicable for F-21 II)

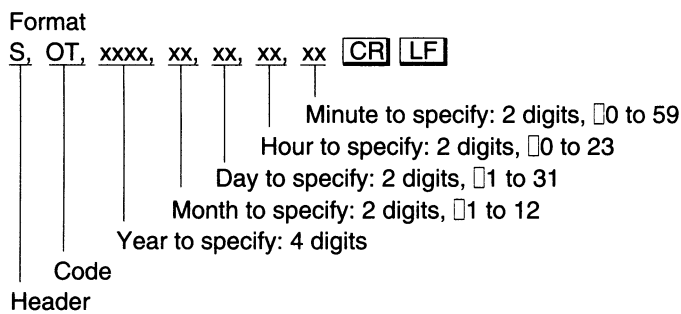


Specifies pH Temperature Conversion



*When Temperature conversion ON/OFF is set to:
 "0: OFF"; □□□□□□
 "1: ON"; -0.100 to □0.100

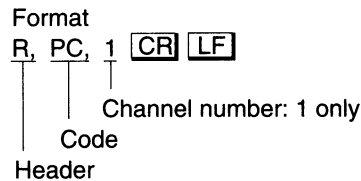
Specifies Time Data



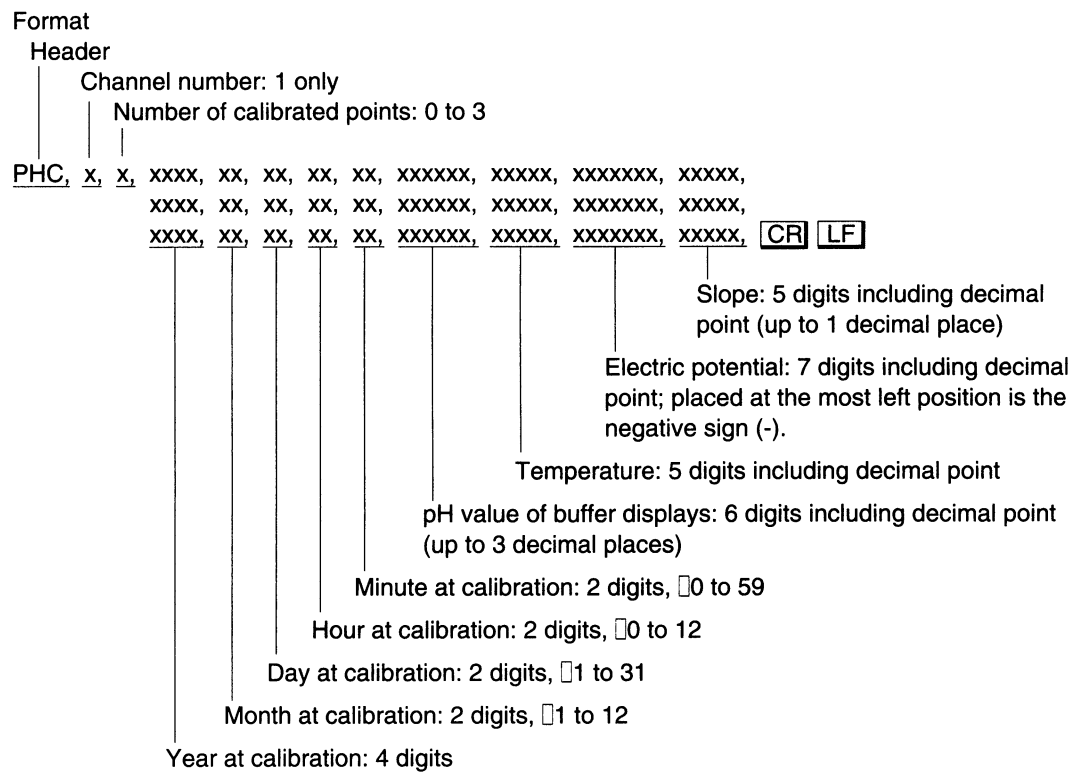
Command to Request Data and Response from pH Meter

Requests pH Calibration Date and Response

Request command



Response from pH meter



- Note**
- The pH value of other buffer is included in the displayed pH values of standard buffers.
 - The format has a fixed length. If no data is available, x is output as .
 - Date and time of the latest calibration are output.

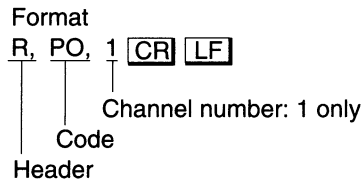
REFERENCE:

Slope data is output as xxx. x in % relative to the theoretical slope between the points.

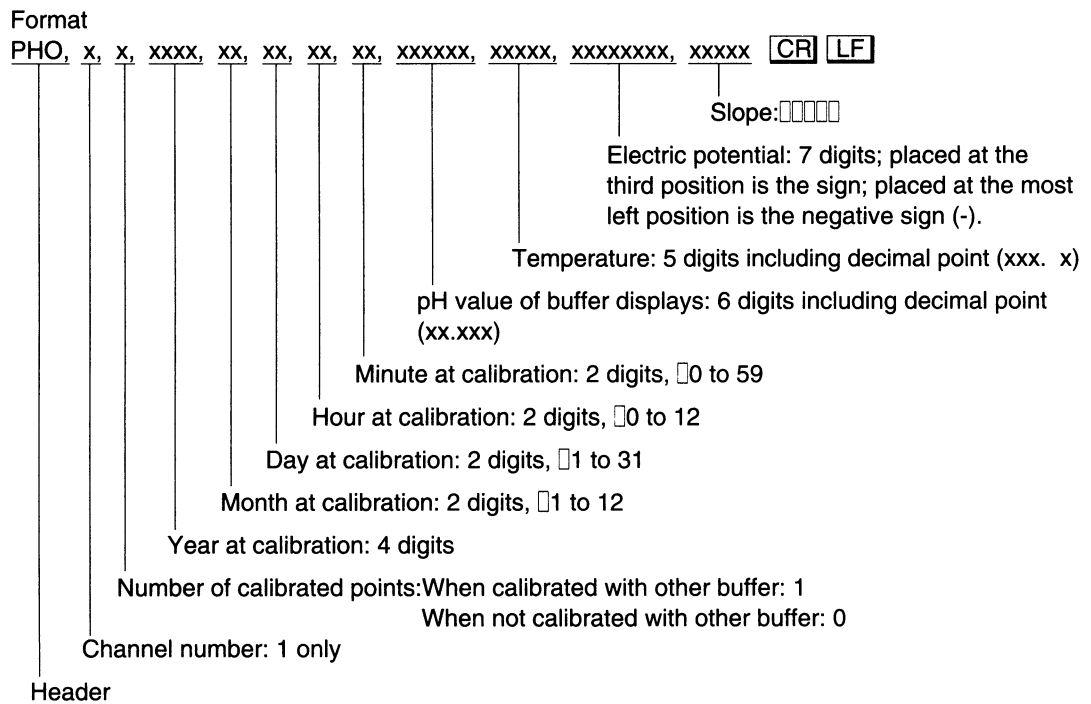
For any value exceeding 999.9 or any negative value, is output. If calibration is in progress, an error is returned.

Requests pH Other Buffer Calibration Value and Response

▶ Request command



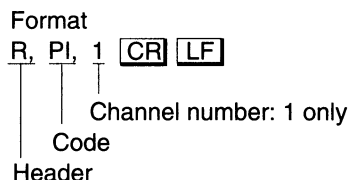
◀ Response from pH meter



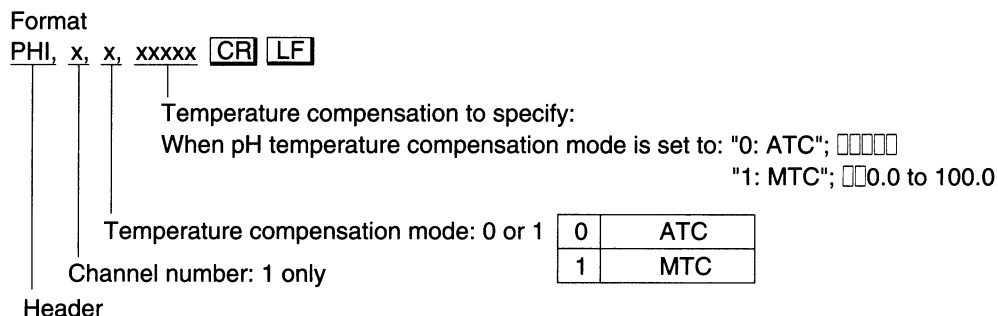
Note The format has a fixed length. If no data is available, x is output as 0. Slope data is output as 0 since the F-21 series perform one-point calibration for other buffer. If calibration is in progress, an error is returned.

Requests the Specified pH Temperature Compensation Value and Response

Request command

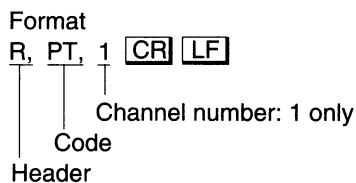


Response from pH meter

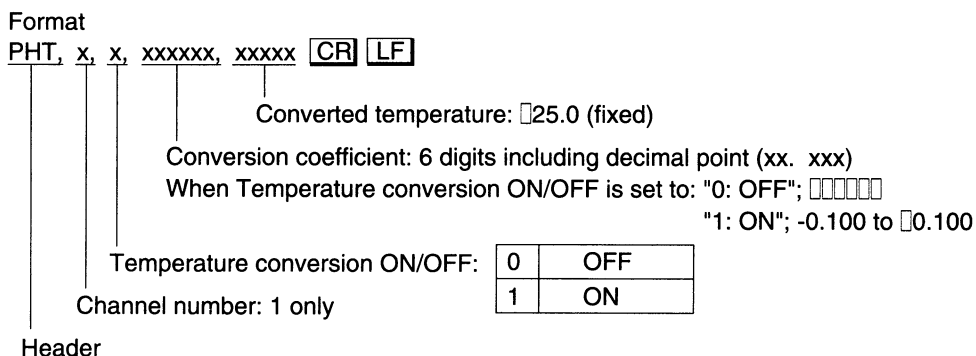


Requests the pH Temperature Conversion Value and Response

Request command



Response from pH meter



Requests the Measured Value and Response

▶ Request command

Format
R, MD CR LF
Code
Header

◀ Response from pH meter

Format
MSD, X, XXXX, XX, XX, XX, XX, X, X, X, XX, X, XXXXXX, X, XXXXXX, XXXXX, XX CR LF

 Error code: 2-digit error number displays (the error with the highest priority is output).
When MEASUREMENT/CALIBRATION Status *1

 Temperature: 5 digits including decimal point (xxx.x)

 mV value: 7 digits including decimal point (xxxxx.x);
-1999.9 to 1999.9

 Ion unit: 1 digit

 Concentration value *2

 Temperature compensation code

0	ATC
1	MTC

 Ion species:

 Channel number: 1 only

 MEASUREMENT/CALIBRATION Status

0	CALIBRATION
1	MEASUREMENT

 Measurement mode

0	pH
1	mV

 Current minute: 2 digits, 0 to 59

 Current hour: 2 digits, 0 to 23

 Current day: 2 digits, 1 to 31

 Current month: 2 digits, 1 to 12

 Current year: 4 digits

 Status

0	HOLD
1	MEASURING

 *1 Measurement/Calibration

0	If an error occurs during measurement, the latest data will continue to output.
1	If an error occurs during calibration, 1 is output.

 *2 Concentration value

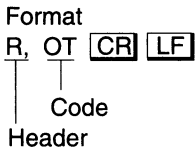
pH	6 digit including decimal point (xxxxxx)
mV	xxxxxx

Heade

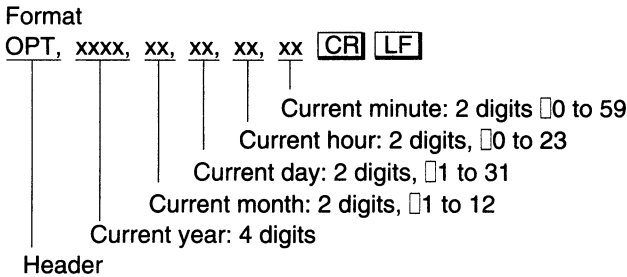
Note For ion species and ion unit, 1 is returned since the F-21 series does not an ion measurement function.

Requests Time Data and Response

▶ Request command



◀ Response from pH meter



Sample Program

Connecting the F-21 Series to a Personal Computer

The external output of the F-21 series pH meter is designed to be compatible with communications via the RS-232C port. A commercially available cross cable can be used. To connect the F-21 series to an NEC PC-9801 series personal computer use a cross cable for 9 pins to 25 pins. (For the specification, refer to page 66.) If the communication conditions must be specified, refer to the instruction manual for the computer.

Sample program

The program shown on page 64 is a sample written in BASIC. The communication conditions are given below:

Baud Rate: 2400 bps

Word Length: 8 bits

Parity: None

Stop Bit: 1 bit

The commands used are briefly described below. For further details, refer to the instruction manual for BASIC.

Some commands cannot be used or are changed over to other commands depending on the version of BASIC.

Note This program was created on an NEC PC-9801 using NEC N-88 BASIC (86).

BASIC commands concerning the use of RS-232C

OPEN statement: The communication conditions are specified and the RS-232C port is opened. To specify the above conditions, enter OPEN "COM:N81NN" AS #1.

CLOSE statement: The RS-232C port is closed.

Command to handle data

PRINT statement: Displays data.

PRINT # statement: Issues a command from the personal computer; personal computer → cable → pH meter

LINE INPUT statement: Reads one line of data that has come via the RS-232C port. (The end of the line is recognized by **CR** + **LF** .)

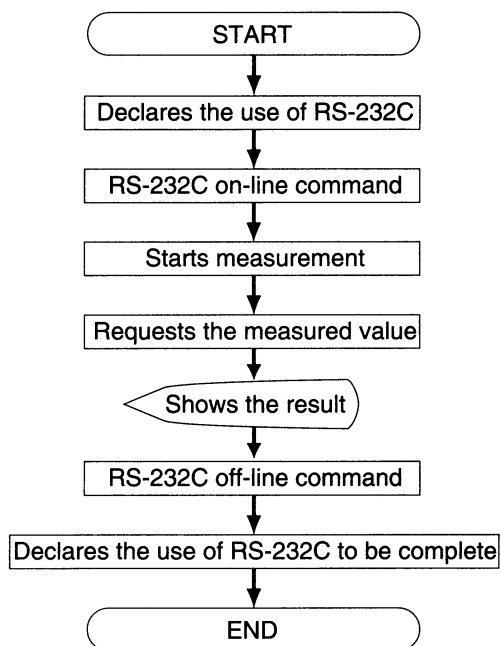
pH meter → cable → personal computer

Other commands

WHILE to WEND statement: Provides repetition depending on conditions. This program determines whether the measured value has been held or not. If not held, the program continues to request the measured value until it is held.

MID\$ statement: Cuts a character string. This statement takes the necessary data from the data returned by the pH meter.

Flow chart of sample program



Sample Program

```

100' SAVE "F-20RS.BAS",A
110' RS-232C test program for F-20 series desktop pH meter
120'
130' Specifies the conditions for off-line measurement.
140' Mode           : pH
150' AUTO HOLD     : ON (standard)
160' Calibration   : OFF
170'
180' Transfer format
190' Baud rate      : 2400 bps, character length : 8 bits
200' Parity        : none, stop bit           : 1 bit
210'
220'
*A ———| 230 OPEN "COM:N81NN"AS#1 'Declares the use of RS-232C.
        | 240'
*B ———| 250 PRINT #1,"C,OL,1"      'RS-232C on-line command
        | 260 LINE INPUT #1,A$      'Receives the result obtained with on-line command.
        | 270 PRINT "on-line command," A$ 'Displays the received data.
        | 280'
*C ———| 290 PRINT #1"C,MS"          'Request to start measurement.
        | 300 LINE INPUT #1A$        'Receives the result obtained with start command.
        | 310 PRINT "start measurement command," A$ 'Displays the received data.
        | 320'
*D-1 —| 330 B$="1"
        | 340 WHILE B$<>"0"
        | 350 T$=TIME$
        | 360 PRINT #1,"R,MD" 'Requests the measured value.
        | 370 LINE INPUT #1,M$ 'Receives the result obtained with start command.
*D-2 —| 380 B$=MID$(M$,5,1) 'Determines whether the measured value has been held.
*D-3 —| 390 IF T$=TIME$ THEN 390 ELSE 400
        | 400 WEND
        | 410 PRINT "pH measurement result"
        | 420 PRINT M$ 'Displays the received data.
        | 430'
        | 440 PRINT #1,"C,OL,0" 'RS-232C off-line command
*E ———| 450 LINE INPUT #1,A$ 'Receives the result obtained with off-line command.
        | 460 PRINT "off-line," A$
        | 470'
*F ———| 480 CLOSE #1
*G ———| 490 END

```

*A: Line 230

Declares the use of RS-232C (specifies the communication condition).

*B: Line 250 to 270

Selects the RS-232C on-line mode.

*C: Line 290 to 310

Starts measurement.

*D-1: Line 330 to 420

Fetches the measured data every second, holds it (AUTO HOLD), and then displays it on the screen of the personal computer.

*D-2: Line 380

Uses the data to determine whether the measured value has been held.

*D-3: Line 390

Waits for one second.

*E: Line 440 to 460

Selects the RS-232C off-line mode.

*F: Line 480

Finishes the use of RS-232C.

*G: Line 490

Finishes the BASIC program.

Modifying the Program

Changing the command to issue to the RS-232C port Modify the following statement which is included in the program and used to transfer commands at the RS-232C port:

```
PRINT #1, "_____"
```

The command in the double quotes is sent to the pH meter. Other commands can be transferred by changing this command.

Considerations To Be Noted in a Modification

To finish the program after issuing the OPEN command which allows the RS-232C port to be used, be sure to execute the CLOSE command.

When using the PRINT # statement, take care not to use a wrong format for the command in the double quotes.

The WHILE to WEND statement is not required. In particular, if a mistake is included in the PRINT # statement, the program may become unable to exit the loop.

RS-232C Specifications

Check with EIA-232-D.

Transfer format (specified in the METER CONDITIONS mode)

Baud rate: 2400 bps

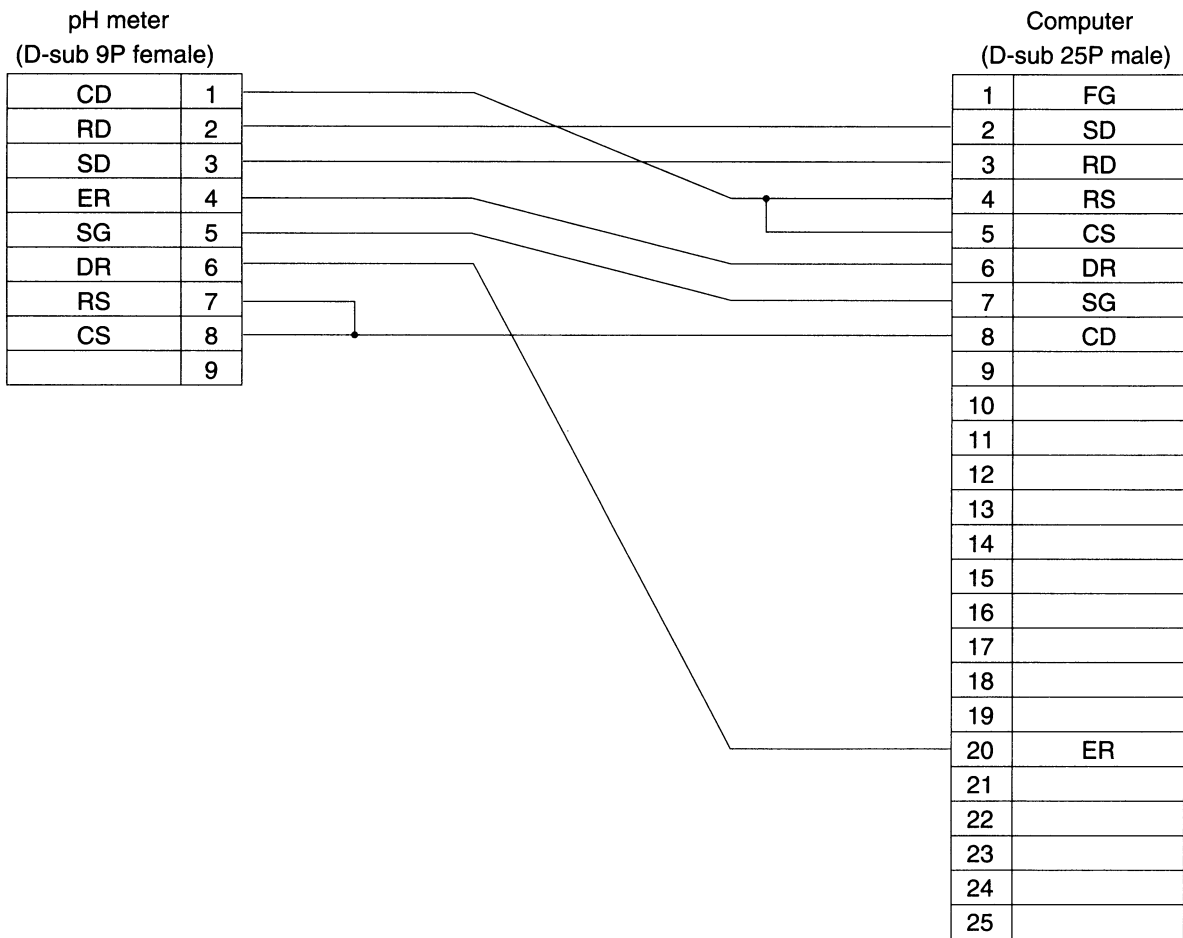
Character length: 8 bits

Parity: None

Stop bit: 1 bit

Communication method: Half duplex

Cable connection



PRINTER

(EXTRA-COST OPTION)

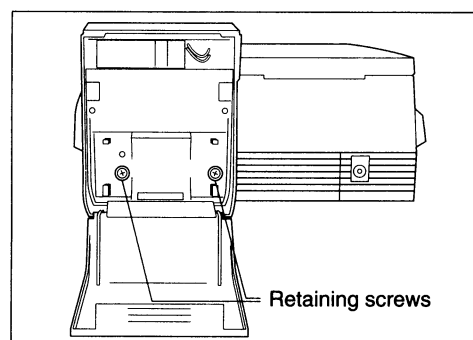
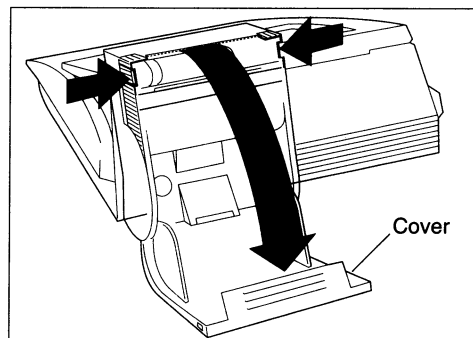
Installing the Printer Unit (EXTRA-COST OPTION)	68
Installing The Printer Unit	68
Loading the Recording Paper	68
Specifications of Printer Output	69
Overview	69
Timing of Output to Printer	69
Print Format for the Calibrated pH Value	70
Print Format for Measured pH Value	70
Print Format for Measured mV Value	71
Print Format at Data Storage and for Stored Data	72

Installing the Printer Unit (EXTRA-COST OPTION)

Installing the Printer Unit

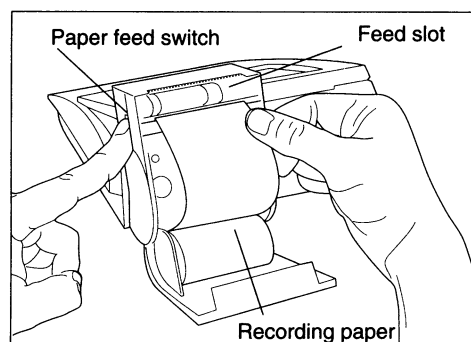
Note Be sure to turn off the pH meter by pressing the **ON/OFF** key.

1. Connect the printer unit to the printer connector located on the rear of the unit.
2. Press both sides marked with an arrow and then open the lid.
3. Tighten the two retaining screws for the printer unit.



Loading the Recording Paper

1. Turn on the pH meter by pressing the **ON/OFF** key.
2. Load the recording paper.
3. Insert the edge of the recording paper into the feed slot and then hold down the paper feed switch.
4. When enough of the recording paper appears allowing you to manually pull it out from the top, release the paper feed switch.
5. Close the lid for the printer unit.



Note If the paper gets jammed, hold down the paper feed switch while pushing the paper into the feed slot, and then remove the jammed portion.

Specifications of Printer Output

Overview

The printer for the F-21 is available as an extra-cost option. When the F-21 is turned on, it detects whether the printer is connected and then determines whether or not to run the printer-related program.

Timing of Output to Printer

Data is output to the printer for the following conditions

- A pH value has been calibrated in the CAL or OTHER CAL mode.

AUTO HOLD mode

When a pH value has been calibrated after the electric potential is stabilized, that calibrated value is printed out.

MANUAL mode

When a momentary value has been calibrated by pressing the **CAL** key, that calibrated value is printed out.

See "Print Format for Measured pH Values."

- When the MEASURING mode has changed to the HOLD mode in the pH MODE screen in either the AUTO or MANUAL mode, the pH value is printed out. See "Print Format for Measured pH Value."
- When the MEASURING mode has changed to the HOLD mode in the mV MODE screen in either the AUTO or MANUAL mode, the mV value is printed out. See "Print Format for Measured mV Value."
- When the **IN/RETURN** key is pressed, the displayed data is printed out in the format used at measurement. See "Print at Data Storage and Print Format for Stored Data."
- When the **IN/RETURN + OUT**. keys are pressed, the displayed data number and subsequent ones are printed out. See "Print at Data Storage and Print Format for Stored Data."

Print Format for the Calibrated pH Value

Format

'93/7/29 19:18	Year (last two figures in calendar year)
CAL. pH 6.865	Calibrated pH value
25.0°C	Temperature in the ATC or MTC mode
** CALIBRATION OK **	Message showing calibration completion

If an error occurs during calibration (ERROR7, 8, or 9)

'93/7/29 19:18	Year (last two figures in calendar year)
CAL. pH 4.008	Calibrated pH value
25.1°C	Temperature in the ATC or MTC mode
** ELECTRODE CHECK **	Error message

- Notes**
- If ERROR5 or 6 occurs during calibration, the data will not print out.
 - If the pH, or temperature value exceeds the display range during calibration, data will not print out because the calibration is no longer performed.
 - If the calibration is aborted in the AUTO HOLD mode, no data is printed out.
 - When the pH meter is set to MTC, the temperature specified for MTC is printed out.

Print Format for Measured pH Value

Format

'93/7/29 19:18	Year (last two figures in calendar year)
pH 12.00	pH value (converted using a temperature coefficient)
M 25.1°C	Temperature in the ATC or MTC mode
'93/7/29 19:18	Year (last two figures in calendar year)
pH ERROR	Out of pH range
M 25.1°C	Temperature in the ATC or MTC mode

- Notes**
- If data exceeds the specified capacity when the **IN/RETURN** key has been pressed, this format is not printed out.
 - If the calibration is aborted in the AUTO HOLD mode, no data is printed out.
 - When TEMP COEF is set to ON, an asterisk is printed out before pH.
 - The pH value is printed out in accordance with the specified resolution.
 - When the pH meter is set to MTC, the temperature specified for MTC is printed out.

Print Format for Measured mV Value

Format

'93/7/29 19:18	Year (last two figures in calendar year)
* -1600 mV	* REL relative mV
100.0°C	Temperature
'93/12/25 19:19	Year (last two figures in calendar year)
mV ERROR	Out of mV range
100.0°C	Temperature

- Notes**
- ERROR is printed out if the mV or temperature value falls out of the allowable range.
 - If data exceeds the specified capacity when the **IN/RETURN** key has been pressed, this format is not printed out.
 - If the calibration is aborted in the AUTO HOLD mode, no data is printed out.
 - When REL mV is set to ON, an asterisk is printed out before mV.

Print Format at Data Storage and for Stored Data

Format

'93/7/29 19:18	Year (last two figures in calendar year)
NO.1 *pH 12.000	Data number, pH value (* converted using a temperature coefficient)
M 100.0°C	Temperature in the ATC or MTC mode
'93/7/29 19:18	Year (last two figures in calendar year)
NO.2 *pH 12.000	Data number, pH value (* converted using a temperature coefficient)
M 25.0°C	ATC or MTC mode
'93/7/29 19:18	Year (last two figures in calendar year)
NO.10 -1999 mV	Data number, mV value
25.0°C	Temperature
'93/7/29 19:18	Year (last two figures in calendar year)
NO.11 -1999 mV	Data number, mV value
0.0°C	Temperature
'93/7/29 19:18	Year (last two figures in calendar year)
NO.21 *pH 12.000	Data number, pH value (* converted using a temperature coefficient)
M 25.0°C	Temperature in the ATC or MTC mode

- Notes**
- If the **IN/RETURN** key is pressed with the printer connected, data is numbered to output in the print format for the measured values.
 - If the **IN/RETURN + OUT**. keys are pressed when stored data is displayed, the displayed stored data and any subsequent data are all printed out. Pressing the **IN/RETURN** key aborts printing data.
 - If there is no data displayed, nothing is printed out.
 - The data is always numbered in series.

APPENDIX

Concerning pH Measurements	74
pH Measurement	74
Temperature Conversion	75
Standard Buffers	76
Measuring ORP (Oxidation-Reduction Potential)	78
What is ORP?	78
Types of Reference Electrodes (comparison electrode) and ORP ...	79
Electric potential sign	79
ORP Standard Buffers	80
Supplies	81
List of Supplies	81
List of Option	81
Specifications	82
pH Meter	82
Electrodes Supplied with the pH Meter	82

Concerning pH Measurements

pH Measurement

pH measurement and temperature

The temperature of the solution is a critical parameter in accurately measuring its pH value. The possible factors for errors as may occur during measurement include the electric potential between the solutions, the asymmetric potential, and the pH of the internal liquid. All of these factors vary depending on the temperature of the solution under measurement. In order to minimize the effect of the error factors, it is the best way to equalize the temperatures of the standard buffers at calibration. For further information, see "JIS Z8802 pH measurement method."

Liquid Junction Potential

Liquid junction potential refers to the difference in potential occurring around a liquid junction. The size of the potential varies depending on the solution, the temperature, and the shape of the liquid junction.

When solutions of different compositions come in contact, ion diffusion occurs at the place of contact, and since size and other factors of the ions concerned differ between solutions, the rate of diffusion also differs.

Due to the ion diffusion, a separation of electric charges occurs where the solutions come in contact, and this is thought to bring about a difference in potential. This potential slows down quick-moving ions, and speeds up slow-moving ions, the end result being that both positive and negative ions are moving at the same speed where the liquids come in contact. It is the electric potential in this balanced state which is referred to as the liquid junction potential. When the liquid junction potential is large, measured values markedly vary from the true values.

Asymmetry Potential

Inside the glass electrode is an internal electrode which contains an internal solution of pH 7. When the electrode is placed in a solution of pH 7, the pH value on both sides of the glass membrane will be identical, so no potential should be produced. In fact, however, an electrode potential is produced, and this potential is known as asymmetry potential.

The size of the asymmetry potential varies depending on such factors as the shape and composition of the glass, any distortion of the glass incurred during manufacture, and also by impurities in the internal solution, and changes in the glass membrane. In addition, when the glass membrane is dry, asymmetry potential increases, and can cause measurement errors.

Temperature Compensation

The electromotive force generated in the glass electrode varies depending on the temperature of the solution. As its name implies, temperature compensation compensates for the variation in electromotive force due to temperature change. It is important to realize here that changes in the pH value of a solution due to temperature changes, and temperature compensation, are completely unrelated phenomena. For this reason, when measuring pH values, even with a pH meter having an automatic temperature compensator, it is necessary to record the temperature of the solution together with the pH value, or the measured results may turn out to be completely meaningless.

Temperature Conversion

Differences between temperature compensation and pH conversion

When carrying out conduction measurements of pH using a glass electrode, the electromotive force generated in the electrode with every 1 pH varies depending on the temperature of the sample (see table). The process of compensating for this electrically is defined as Temperature Compensation, and only a pH meter equipped with this function can determine the pH value of a sample at the temperature at which it is measured.

Electrode Potential (Electromotive Force) with Every 1 pH < JIS Z8802-1978 >

Temp.(°C)	2.3026RT/FmV	Temp.(°C)	2.3026RT/FmV
0	54.20	35	61.15
5	55.19	40	62.14
10	56.19	45	63.13
15	57.18	50	64.12
20	57.17	55	65.11
25	59.16	60	66.11
30	60.15	65	67.10

Though it is possible with temperature compensation to find the pH of a sample of a given temperature, since the pH varies depending on the temperature, it is not possible to find the pH of the same sample at a different temperature. The conversion of the pH of a sample at a given temperature to the pH at another temperature is called Temperature Conversion, and is distinguished from Temperature Compensation.

pH Conversion of Sample Solution

The pH of a sample possesses particular characteristics at different temperatures. This is because the physical properties of the sample vary according to the temperature. The figure below shows one example of the temperature-related characteristics of the pH of pure water. As the temperature of the water rises, the pH value shifts toward acidity. When using a pH meter, this shift in electromotive force is what is measured by the meter. By correcting the pH change due to temperature change, it is possible to determine the pH value of a sample at a particular temperature. The F-series converts the pH value of a sample to the value at 25°C.

Calculating the Temperature Coefficient

The temperature coefficient of the sample is determined by the following formula:

$$\alpha = (\text{pH}_t - \text{pH}_{25}) / (t - 25) \text{ [pH/}^\circ\text{C]}$$

where, pH_{25} : pH value at 25°C

pH_t : pH value at t°C

α : temperature conversion value [pH/°C]

Note that erroneous measurements may be obtained when the pH-temperature relationship of the sample is not linear, or the temperature conversion coefficient is not constant (such as when the pH varies even at the same temperature).

Standard Buffers

Using standard buffers

The standard buffers are used to calibrate the scale of the pH meter before measuring the pH value of an unidentified solution. Therefore, various combinations of pH 4, 7, and 9 standard buffers should be used in accordance with the conditions of the liquid to be measured.

- When you want to know the approximate pH value (one-point calibration):
Use the standard buffer of pH 7 or a standard buffer whose pH value is close to that of the liquid to be measured.
- When it is previously known whether the liquid under measurement is acid or alkaline (two-point calibration):
For acid liquid: Use the pH 4 and 7 standard buffers.
For alkaline liquid: Use the pH 7 and 9 standard buffers.
- When the pH value of the liquid under measurement is unknown (three-point calibration):
Use the pH 4, 7, and 9 standard buffers.
- Otherwise, the two-point or three-point calibration can be carried out using various combinations of pH 2, 4, 7, and 12 standard buffers in accordance with the pH value of the liquid to be measured.

Note Use pH 10 instead of pH 9 to some regions or countries.

pH Values of Standard Buffers at Temperatures

Temperature (°C)	pH oxalate	pH 4 phthalate	pH 7 neutral phosphate	pH 7 neutral phosphate	pH 10 Carbonate	pH 12 sat calcium hydroxide solution
0	1.666	4.003	6.984	7.119	9.464	13.423
5	1.668	3.999	6.951	7.086	9.395	13.207
10	1.670	3.998	6.923	7.058	9.332	13.003
15	1.672	3.999	6.900	7.035	9.276	12.810
20	1.675	4.002	6.881	7.015	9.225	12.627
25	1.679	4.008	6.865	7.000	9.180	12.454
30	1.683	4.015	6.853	6.988	9.139	12.289
35	1.688	4.024	6.844	6.979	9.102	12.133
38	1.691	4.030	6.840	6.973	9.081	12.043
40	1.694	4.035	6.833	6.969	9.068	11.984
45	1.700	4.047	6.834	6.968	9.038	11.841
50	1.707	4.060	6.833	6.970	9.011	11.705
55	1.715	4.075	6.834	6.980	8.985	11.574
60	1.723	4.091	6.836	6.990	8.962	11.499
70	1.743	4.126	6.845	7.000	8.921	
80	1.766	4.164	6.859	7.020	8.885	
90	1.792	4.205	6.877	7.030	8.850	
95	1.806	4.227	6.886		8.883	

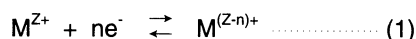
Note There are two types of buffers: pH value 6.865 and 7.000 of standard buffer at 25°C. The F-20 has setting with either of these values for calibration in accordance with region and country.

Measuring ORP (Oxidation-Reduction Potential)

What is ORP?

ORP, an abbreviation of oxidation-reduction potential, means the energy level (electric potential) that is determined by the equilibrium state between oxidant ($M^{(Z-n)+}$) and reluctant which coexist in a solution.

One type of equilibrium state in a solution



When only the state represented by (1) exists, immerse an electrode of a precious metal such as platinum and gold in this solution and form the battery-driven circuit as shown in Fig. 1.

When the electromotive force between both electrodes is measured, it will be represented by the following equation:

$$E = E_0 - \frac{RT}{nF} \ln \frac{a_{M^{(Z-n)+}}}{a_{M^{Z+}}} \dots\dots\dots (2)$$

where, a: Activity, E_0 : Constant

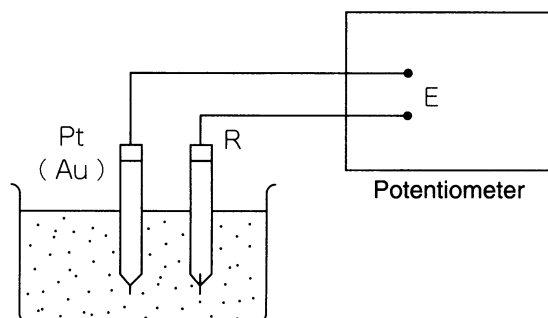
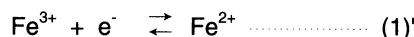


Fig. 1 ORP measuring system

For example, equations (1) and (2) for a solution in which trivalent and bivalent iron oxides coexist are as follows:



$$E = E_0 - \frac{RT}{F} \ln \frac{a_{Fe^{2+}}}{a_{Fe^{3+}}} \dots\dots\dots (2)'$$

When only one type of equilibrium state (1) exists in a solution, the ORP of this solution is uniquely determined by equation (2). However, since many types of equilibrium states actually coexist between various types of ions, the ORP of such a solution cannot be shown by a simple equation and its physical and chemical meanings are not so significant.

For this reason, the ORP measurement should be considered to only provide one scale that shows the characteristics of the solution. However, the ORP measurement is widely used to obtain useful indexes for the analysis of solutions (potentiometric titration) and the disposal of waste liquid.

Types of Reference Electrodes (comparison electrode) and ORP

Since the ORP obtained from a measurement is relative to the comparison electrode, the measured ORP value of the same solution varies depending on the type of comparison electrode. Our comparison electrode is a Ag/AgCl internal electrode using 3.33mol/L KCl for its internal liquid. General scientific papers often show that the normal hydrogen electrode (N.H.E.) was used as a reference electrode. Its relation with the ORP values obtained using the 3.3mol/L KCl-Ag/AgCl electrode is shown by the following equation:

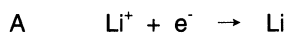
$$E_{\text{N.H.E.}} = E + 206 - 0.7 (t - 25) \text{ mV} \quad t = 0^\circ \text{ to } 60^\circ\text{C}$$

$E_{\text{N.H.E.}}$: The measured ORP value obtained using the normal hydrogen electrode(N.H.E.) as a comparison electrode

E: The measured ORP value obtained using the 3.33mol/L KCl-Ag/AgCl as a comparison electrode

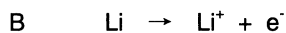
Electric potential sign

Some books on electrochemistry and analytical chemistry include the following information:



$$E_0 = -3.024\text{V} \quad \text{vs.} \quad \text{NHE}$$

However, the other books specify the positive and negative signs reversely as follows:



$$E_0 = -3.024\text{V} \quad \text{vs.} \quad \text{NHE}$$

The expression as in B is essentially the same as A because the reaction direction is only reversed, but it may cause confusion. The expression as in A is adopted in a majority of countries over the world and our notation concerning ORP uses the above format, A.

ORP Standard Buffers

ORP standard buffers are used to check whether the ORP electrode and the pH meter work properly or not. We offer two types of powder for ORP standard buffers as shown.

Model, 160-22: Phthalate added with quinhydrone
 160-51: Neutral phosphate added with quinhydrone

Add one bag of the 160-22 or 160-51 to 250 mL of deionized water and stir it well. At this time, some excessive quinhydrone will be floating on the water surface. Immerse the ORP electrode in this ORP standard buffer to measure its mV value. When the electrode and the pH meter operate normally, one of the values listed in Table 2 and a reading matching within ± 15 mV will be obtained in accordance with the temperature of the standard buffer. If that reading is not obtained, take the following actions:

- Replace the internal liquid in the comparison electrode.
- Immerse the electrode in nitric acid (diluted to half concentration with water) and then rinse it well with deionized water.
- Polish the surface of the platinum electrode with fine sand paper No. 1000 and then rinse it well with deionized water.

If any reading matching within ± 15 mV is not obtained after every action was taken, the electrode or the pH meter may be abnormal. Therefore, replace the electrode or check the pH meter.

- Notes**
- The ORP standard buffer is not intended for use to calibrate the pH meter.
 - If the prepared ORP standard buffer is allowed to stand in air for more than one hour, it might change in quality. Therefore, the prepared ORP standard buffer cannot be preserved.

Table 2 Value (mV) of ORP standard buffer at each temperature

Temperature of standard buffer	Standard buffer	
	160-22	160-51
0	+277.5	+116.5
5	+274.2	+111.9
10	+270.9	+106.9
15	+266.8	+101.0
20	+262.5	+ 95.0
25	+257.6	+ 89.0
30	+253.5	+ 82.7
35	+248.6	+ 76.2
40	+243.6	+ 69.0

Comparison electrode: 3. 33MKCl-Ag/AgCl

Supplies

List of Supplies

Part name	Type	Item No.	Remarks
pH electrode	9610-10D	9096-0002-00	Single type electrode of F-20 accessories
	6366-10D	9003-0117-00	Single type precision electrode
	6367-10D	9003-0118-00	Single type super-precision electrode
	6377-10D	9003-0141-00	Single type electrode for low conductivity and non-aqueous solutions
	1076A-10C	9003-0142-00	Glass electrode for low conductivity and non-aqueous solutions
Metal electrode	6861-10C	9003-0131-00	Composite type platinum electrode
	6860-10C	9003-0132-00	Composite type platinum electrode for trace amounts
	3060-10C	9003-0133-00	Single-polarity type platinum electrode
Comparison electrode	2060A-10T	9003-0123-00	Standard type
	2565A-10T	9003-0127-00	Double junction type
Temperature compensation electrode	4163-10T	9003-0130-00	For temperature compensation and temperature measurement
Set of standard pH buffers	101-S	9003-0035-00	
Standard pH buffer			Precision ± 0.02 pH
pH2	100-2	9003-0015-00	
pH4	100-4	9003-0016-00	
pH7	100-7	9003-0017-00	
pH9	100-9	9003-0018-00	
pH10	100-10	9003-0019-00	
Concentrated standard pH buffer			Precision ± 0.02 pH
pH4	110-4	9003-0023-00	
pH7	110-7	9003-0024-00	
pH10	110-10	9003-0025-00	
Standard pH buffer for precise measurement			Precision ± 0.003 pH, based on N.B.S.
pH4	100-B4	9003-0020-00	
pH7	100-B7	9003-0021-00	For medical pH
pH9	100-B9	9003-0022-00	
Powder for pH standard buffer			Precision ± 0.05 pH
pH2	150-2	9003-0026-00	
pH4	150-4	9003-0027-00	
pH7	150-7	9003-0028-00	
pH9	150-9	9003-0029-00	
Powder for ORP standard buffer	160-51	9003-0031-00	ORP value: 95mV (silver-chloride-proof electrode, 20°C)
	160-22	9003-0030-00	ORP value: 262mV (silver-chloride-proof electrode, 20°C)
Internal liquid for comparison electrode	300	9003-0035-00	
AC adapter	AC-10	9078-0001-00	100V

List of Option

Part name	Type
Printer	FP-20
Electrode stand	FA-20S

Supplies and options can be obtained at special agents by specifying their part names, types, and item numbers.

Specifications

pH Meter

Measurement method	Glass electrode method
Measurable range	
pH	pH 0.00 to 14.00
mV	±1600 mV
Temperature	0.0 to 100.0°C
Resolution	
pH	0.01/0.1pH *
mV	1mV
Temperature	0.1°C
Repeatability	0.01pH±1digit
Temperature compensation range	0 to 100°C
Recorder output	
pH	±700 mV (pH0 to 14)
mV	±800 mV (±1600mV)
Temperature	1000 mV (0 to 100°C)
Output impedance	1 kΩ or less
RS-232C Input/Output	
Baud rate	2400 bps
Word length	8 bits
Parity	none
Stop bit	1 bit
Communication	Half duplex
Power supply	AC 100V 50/60Hz
Power consumption	Approx. 0.5 VA
Ambient temperature	0 to 45°C
Dimensions	197(W)×84(H)×246(D)mm
Mass	Approx. 1.0 kg

* 0.1pH resolution is excepted for F-21 □

Electrodes Supplied with the pH Meter

pH range	pH 0 to 14
Temperature	0 to 80°C
Liquid junction	Ceramic
Electrode length	150 mm
Inner electrode	Ag-AgCl electrode
Cable length	1 m
Outer tube	12 mm O.D.



HORIBA

HORIBA, Ltd.

Miyanohigashi, Kisshoin, Minami-ku, Kyoto, Japan
Phone: 81 (75) 313-8123 / Facsimile: 81 (75) 321-5725