Instruction Manual

Model PH402G pH Converter

EXA

YOKOGAWA

IM 12B6B3-E-E
8th Edition

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PREFACE

PREFACE

WARNING

Electric discharge
The EXA analyzer contains devices that can be damaged by electrostatic discharge. When servicing this equipment, please observe proper procedures to prevent such damage. Replacement components should be shipped in conductive packaging. Repair work should be done at grounded workstations using grounded soldering irons and wrist straps to avoid electrostatic discharge.

Installation and wiring
The EXA analyzer should only be used with equipment that meets the relevant IEC, American or Canadian standards. Yokogawa accepts no responsibility for the misuse of this unit.

CAUTION

The Instrument is packed carefully with shock absorbing materials, nevertheless, the instrument may be damaged or broken if subjected to strong shock, such as if the instrument is dropped. Handle with care.

Although the instrument has a weatherproof construction, the transmitter can be harmed if it becomes submerged in water or becomes excessively wet.

Do not use an abrasive or solvent in cleaning the instrument.

Notice
Contents of this manual are subject to change without notice. Yokogawa is not responsible for damage to the instrument, poor performance of the instrument or losses resulting from such, if the problems are caused by:

- Improper operation by the user.
- Use of the instrument in improper applications
- Use of the instrument in an improper environment or improper utility program
- Repair or modification of the related instrument by an engineer not authorized by Yokogawa.

Warranty and service
Yokogawa products and parts are guaranteed free from defects in workmanship and material under normal use and service for a period of (typically) 12 months from the date of shipment from the manufacturer. Individual sales organisations can deviate from the typical warranty period, and the conditions of sale relating to the original purchase order should be consulted. Damage caused by wear and tear, inadequate maintenance, corrosion, or by the effects of chemical processes are excluded from this warranty coverage.

In the event of warranty claim, the defective goods should be sent (freight paid) to the service department of the relevant sales organisation for repair or replacement (at Yokogawa discretion). The following information must be included in the letter accompanying the returned goods:

- Part number, model code and serial number
- Original purchase order and date
- Length of time in service and a description of the process
- Description of the fault, and the circumstances of failure
- Process/environmental conditions that may be related to the installation failure of the device
- A statement whether warranty or non-warranty service is requested
- Complete shipping and billing instructions for return of material, plus the name and phone number of a contact person who can be reached for further information.

Returned goods that have been in contact with process fluids must be decontaminated/disinfected before shipment. Goods should carry a certificate to this effect, for the health and safety of our employees. Material safety data sheets should also be included for all components of the processes to which the equipment has been exposed.

1. INTRODUCTION AND GENERAL DESCRIPTION

The Yokogawa EXA 402 is a 4-wire transmitter designed for industrial process monitoring, measurement and control applications. This instruction manual contains the information needed to install, set up, operate and maintain the unit correctly. This manual also includes a basic troubleshooting guide to answer typical user questions.

Yokogawa can not be responsible for the performance of the EXA analyzer if these instructions are not followed.

1-1. Instrument Check

Upon delivery, unpack the instrument carefully and inspect it to ensure that it was not damaged during shipment. If damage is found, retain the original packing materials (including the outer box) and then immediately notify the carrier and the relevant Yokogawa sales office.

Make sure the model number on the nameplate affixed to the top of the display board of the instrument agrees with your order.

NOTE:
The nameplate will also contain the serial number and power supply selection.
Be sure to apply correct power to the unit.

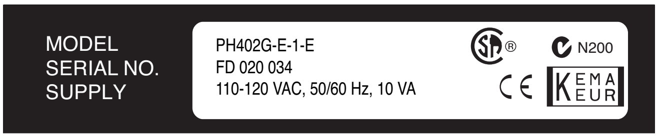


Figure 1-1. Nameplate

Check that all the parts are present, including mounting hardware, as specified in the option codes at the end of the model number. For a description of the model codes, refer to Chapter 2 of this manual under General Specifications.

Basic Parts List: Converter EXA 402
Instruction Manual (See model code for language)
Packet with special cable grommet and blanking pieces
Packet with 4 screws for mounting on a panel (M6x8mm)
Optional mounting hardware when specified (See model code)

1-2. Application

The EXA converter is intended to be used for continuous on-line measurement in industrial installations. The unit combines simple operation and microprocessor-based performance with advanced self-diagnostics and enhanced communications capability to meet the most advanced requirements. The measurement can be used as part of an automated process control system. It can also be used to indicate dangerous limits of a process, to monitor product quality, or to function as a simple controller for a dosing/neutralisation system.

Yokogawa designed the EXA analyzer to withstand harsh environments. The converter may be installed either indoors or outside because the IP65 (NEMA4X) housing and cabling glands ensure the unit is adequately protected. The flexible polycarbonate window on the front door of the EXA allows pushbutton access to the keypad, thus preserving the water and dust protection of the unit even during routine maintenance operations.
A variety of EXA hardware is optionally available to allow wall, pipe, or panel mounting. Selecting a proper installation site will permit ease of operation. Sensors should normally be mounted close to the converter in order to ensure easy calibration and peak performance. If the unit must be mounted remotely from the sensors, WF10 extension cable can be used up to a maximum of 50 metres (150 feet) with a BA10 junction box. Except installations with dual high impedance sensors, where the maximum cable length is 20 metres using integral cable only (no junction box).

The EXA is delivered with a general purpose default setting for programmable items. (Default settings are listed in Chapter 5 and again in Chapter 10). While this initial configuration allows easy start-up, the configuration should be adjusted to suit each particular application. An example of an adjustable item is the type of temperature sensor used. The EXA can be adjusted for any one of five different types of temperature sensors.

To record such configuration adjustments, write changes in the space provided in Chapter 10 of this manual. Because the EXA is suitable for use as a monitor, a controller or an alarm instrument, program configuration possibilities are numerous.

Details provided in this instruction manual are sufficient to operate the EXA with all Yokogawa sensor systems and a wide range of third-party commercially available probes. For best results, read this manual in conjunction with the corresponding sensor instruction manual.

Yokogawa designed and built the EXA to meet the CE regulatory standards. The unit meets or exceeds stringent requirements of EN 55082-2, EN55022 Class A and low voltage safety directive IEC1010 without compromise, to assure the user of continued accurate performance in even the most demanding industrial installations.

2. PH402 SPECIFICATIONS

2-1. General

A. Input specifications

: Dual high impedance inputs (2 x $10^{13}\Omega$) with provision for liquid earth connection. Suitable for inputs from glass or enamel pH & reference sensors and ORP metal electrodes.

B. Input ranges

- pH : -2 to 16 pH
- ORP : -1500 to 1500 mV
- rH : 0 to 55 rH
- Temperature : -30 to 140 ºC (-20 -to 300 ºF) (for 8k55 sensor -10 to 120 ºC (10 to 250 ºF); for 10kPTC sensor -20 to 140 ºC (0 to 300 ºF))

C. Span

- pH	: min 1	max 20 pH
- ORP	: min 100	max 2000 mV
- rH	: min 2	max 55 rH
- Temperature	: min 25 ºC	max 200 ºC
	min 50 ºF	max 400 ºF
	(for 8k55 sensor max 100 ºC (250 ºF))	

D. Transmission Signals

: Two isolated outputs of 0/4-20 mA DC with common negative.
Maximum load 600 Ω.
Auxiliary output can be chosen from pH, temperature, ORP or rH (with suitable sensor), P.I. control. burn up (22 mA) or burn down (0/3.5 mA) to signal failure.

E. Temperature compensation

- Range : Automatic or manual compensation to Nernst equation.
  Process compensation by configurable temperature coefficient.
  Adjustable ITP (Isothermal point of intersection).

F. Calibration

: Semi-automatic using preconfigured NIST buffer tables 4, 7 & 9, or with user defined buffer tables, with automatic stability check.
Manual adjustment to grab sample.
Slope and Asymmetry Potential setting.
Zero point can be selected for calibration and display instead of As. Pot. (IEC746-2)

G. Serial Communication

: Bi-directional according to the EIA-485 standard using HART protocol and PC402 software.

H. Logbook

: Software record of important events and diagnostic data. Available through RS485, with key diagnostic information available in the display.

I. Display

: Custom liquid crystal display, with a main display of 3½ digits 12.5 mm high. Message display of 6 alphanumeric characters, 7 mm high. Warning flags and units (pH and mV) as appropriate.

J. Contact outputs

- General : Four (4) SPDT relay contacts with LED indicators. For S1, S2, and S3, the LED is on when relay is powered.
  NOTE: For S4 (FAIL) LED lights when power is removed (Fail safe).
  Contact outputs configurable for hysteresis and delay time.
- Switch capacity : Maximum values 100 VA, 250 VAC, 5 Amps.
  Maximum values 50 Watts, 250 VDC, 5 Amps.
- Status : High/Low process alarms, selected from pH, ORP, rH and temperature.
  Contact output is also available to signal “Hold Active”
- Control function : On / Off
  PI pulsed: Proportional duty cycle control with integral term.
  PI frequency: Proportional frequency control with integral term. In addition wash cleaning control signal on S3, and FAIL alarm for system and diagnostic errors on S4

K. Contact input : Remote wash cycle start.

L. Power supply : 230 VAC ±15%, 50/60 Hz.
Max. consumption 10 VA.
115 VAC ±15%, 50/60 Hz.
Max. consumption 10 VA.
100 VAC ± 15% 50/60 Hz.
Max. consumption 10 VA.
24 VDC -20% / +30%
Max. consumption 10 Watts.

M. Input isolation : 1000 VDC

N. Shipping details: Package size w x h x d
290 x 225 x 170 mm.
11.5 x 8.9 x 6.7 in.
Packed weight approx.
2.5 kg (5lb).

2-2. Operating specifications

A. Performance : pH
- Linearity : ≤0.01 pH ± 0.02 mA
- Repeatability : ≤0.01 pH ± 0.02 mA
- Accuracy : ≤0.01 pH ± 0.02 mA

Performance : ORP
- Linearity : ≤1 mV ± 0.02 mA
- Repeatability : ≤1 mV ± 0.02 mA
- Accuracy : ≤1 mV ± 0.02 mA

Performance : Temperature with Pt1000 Ω, 3 kΩ Balco, 5 k1Ω and 10k PTC
- Linearity : ≤0.2 °C ± 0.02 mA
- Repeatability : ≤0.1 °C ± 0.02 mA
- Accuracy : ≤0.3 °C ± 0.02mA

Performance : Temperature with Pt100 Ω & 8k55Ω
- Linearity : ≤0.3 °C ± 0.02 mA
- Repeatability : ≤0.1 °C ± 0.02 mA
- Accuracy : ≤0.4 °C ± 0.02 mA

B. Ambient operating temperature
: -30 to +70 °C (-20 to 160 °F) for mA output.
-10 to +70 °C (10 to 160 °F) for LCD

C. Storage temperature
: -30 to +70 °C (-20 to 160 °F)

D. Humidity : 10 to 90% RH non-condensing

E. Housing
Case : Cast aluminium with chemically resistant coating
Cover : flexible polycarbonate window.
Case color : off-white and
Cover color : moss green.
Cable entry : via six ½” polyamide glands.
Cable terminals : are provided for up to 2.5 mm^2 finished wires.
Protection : weather resistant to IP65 and NEMA 4X standards.
Mounting : Pipe wall or panel, using optional hardware.

F. Data protection : EEPROM for configuration and logbook, and lithium battery for clock.

G. Watchdog timer: Checks microprocessor

H. Automatic safeguard
: Return to measuring mode when no keystroke is made for 10 min.

I. Power interruption
: Less than 50 milliseconds no effect. More than 50 milliseconds reset to measurement.

J. Operation protection
: 3-digit programmable password.

K. Regulatory compliance
- EMC : meets council directive 89/336/EEC
- Emmission : meets EN 55022 Class A
- Immunity : meets EN 50082-2
- Low voltage : meets council directive 73/23/EEC
- Installation : Designed for installation conforming to IEC 1010-1. Category II.

2-3. Model and suffix codes

Model	Suffix	Option code	Description
PH402G			pH/ORP transmitter
	-E		Always E
Supply voltage	-1		115 Volts 50/60 Hz
	-2		230 Volts 50/60 Hz
	-4		24 Volts DC
	-5		100 Volts 50/60 Hz
Instruction manual	-E		English language *
Options		/U	Pipe and wall mounting hardware
		/PM	Panel mounting hardware
		/Q	Quality certificate
		/SCT	Stainless steel tag

* For other languages contact local sales office

3. INSTALLATION AND WIRING

3-1. Installation and dimensions

3-1-1. Installation site

The EXA converter is weatherproof and can be installed inside or outside. It should, however, be installed as close as possible to the sensor to avoid long cable runs between sensor and converter. In any case, the cable length should not exceed 50 meters (162 feet). Select an installation site where:

- Mechanical vibrations and shocks are negligible
- No relay/power switches are in the direct environment
- Access is possible to the cable glands (see figure 3-1)
- The transmitter is not mounted in direct sunlight or severe weather conditions
- Maintenance procedures are possible (avoiding corrosive environments)

The ambient temperature and humidity of the installation environment must be within the limits of the instrument specifications. (See chapter 2).

3-1-2. Mounting methods

Refer to figures 3-2 and 3-3. Note that the EXA converter has universal mounting capabilities:

- Panel mounting using optional brackets
- Surface mounting on a plate (using bolts from the back)
- Wall mounting on a bracket (for example, on a solid wall)
- Pipe mounting using a bracket on a horizontal or vertical pipe (maximum pipe diameter 50 mm)

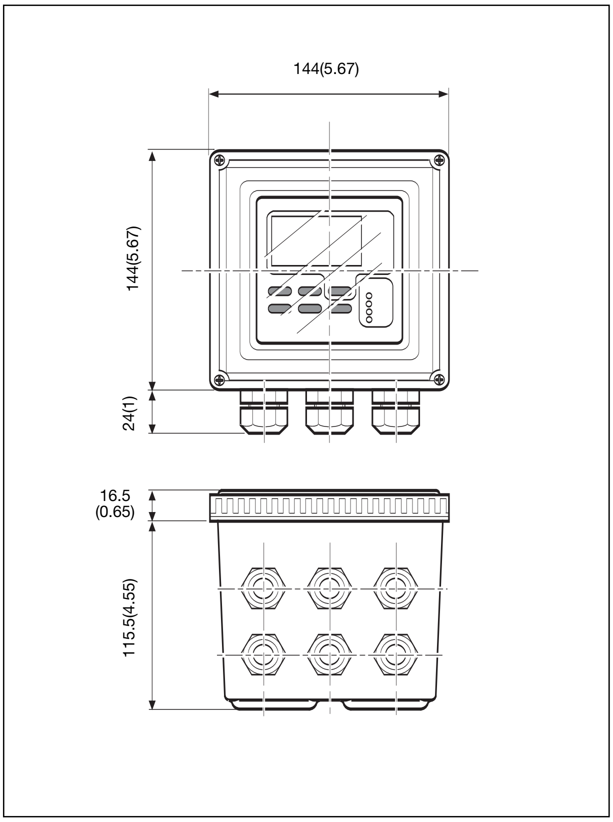


Figure 3-1. Housing dimensions and layout of glands

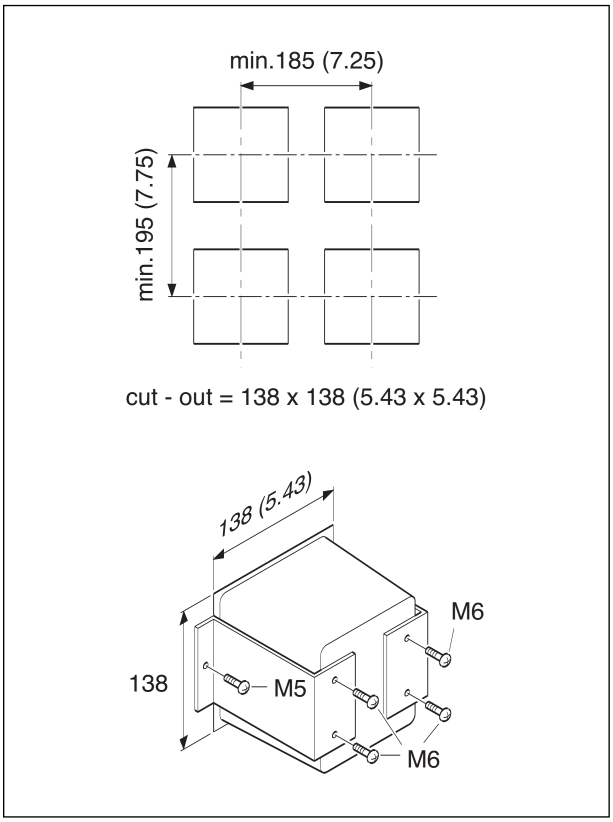


Figure 3-2. Panel mounting diagram

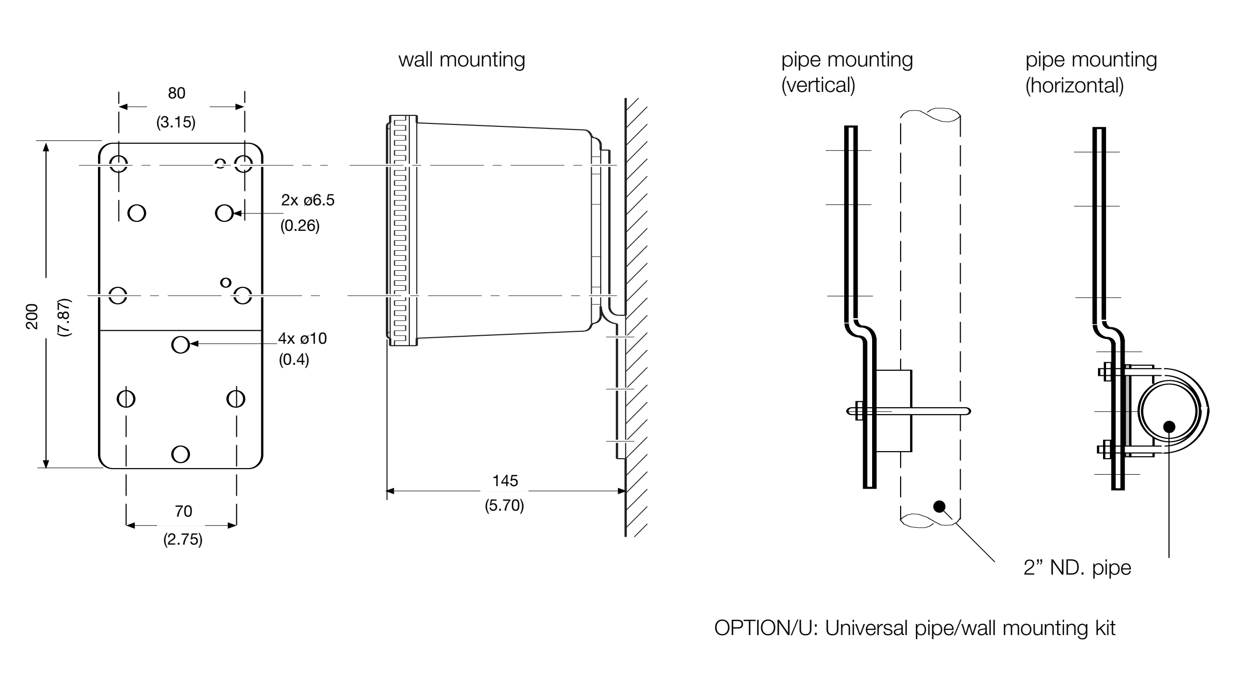


Figure 3-3. Wall and pipe mounting diagram

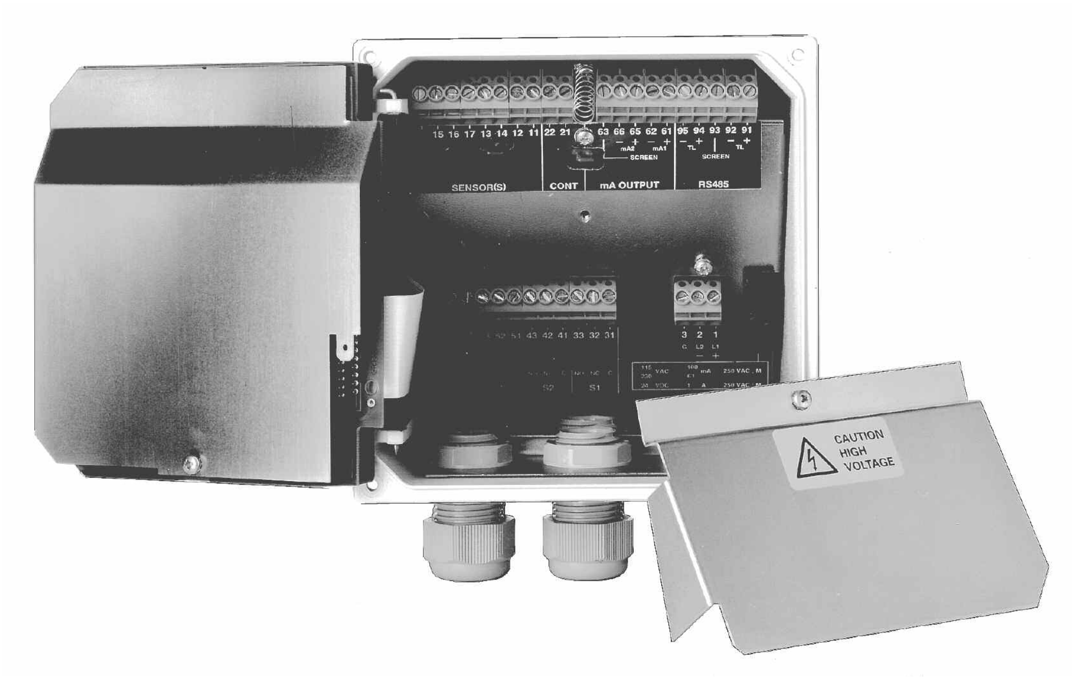


Figure 3-4. Internal view of EXA wiring compartment

3-2. Preparation

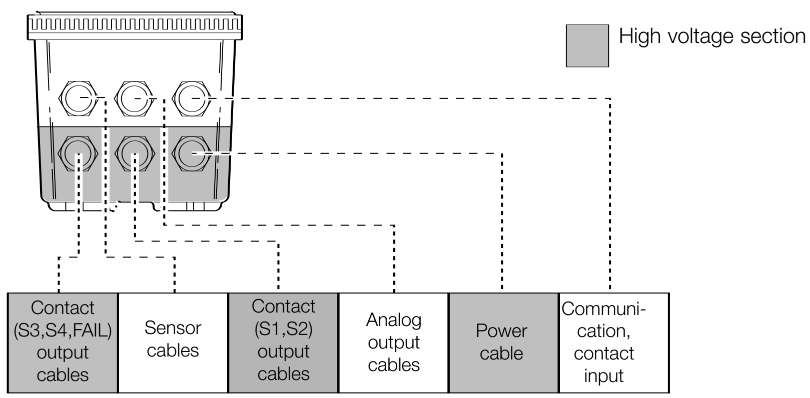
Refer to figure 3-4. The relay contact terminals and power supply connections are under the screening (shielding) plate. These should be connected first. Connect the sensor, outputs and data communication connections last.

To open the EXA 402 for wiring:

1. Loosen the four frontplate screws and remove the cover.
2. Use the rubber knob in the lower righthand corner and swing open the display board to the left.
3. The upper terminal strip is now visible.
4. Remove the screen (shield) plate covering the lower terminal strip.
5. Connect the power supply and contact outputs. Use the three glands at the back for these cables.
6. Replace the screen (shield) plate over the lower terminals.

WARNING Always replace the screen plate over the power and contact outputs for safety and avoid interference.

7. Connect the analog output(s), the sensor input, and, if necessary, the RS485 serial bus.
8. Use the front three glands for analog output, sensor input, contact input and communication cabling (see figure 3-5).
9. Close the display board and switch on the power. Commission the instrument as required or use the default settings.
10. Replace the cover and secure frontplate with the four screws.



Suitable for cables with an outside diameter between 7 - 12 mm ($^{9}/_{32}$ - $^{15}/_{32}$ in.)

Figure 3-5. Glands to be used for cabling

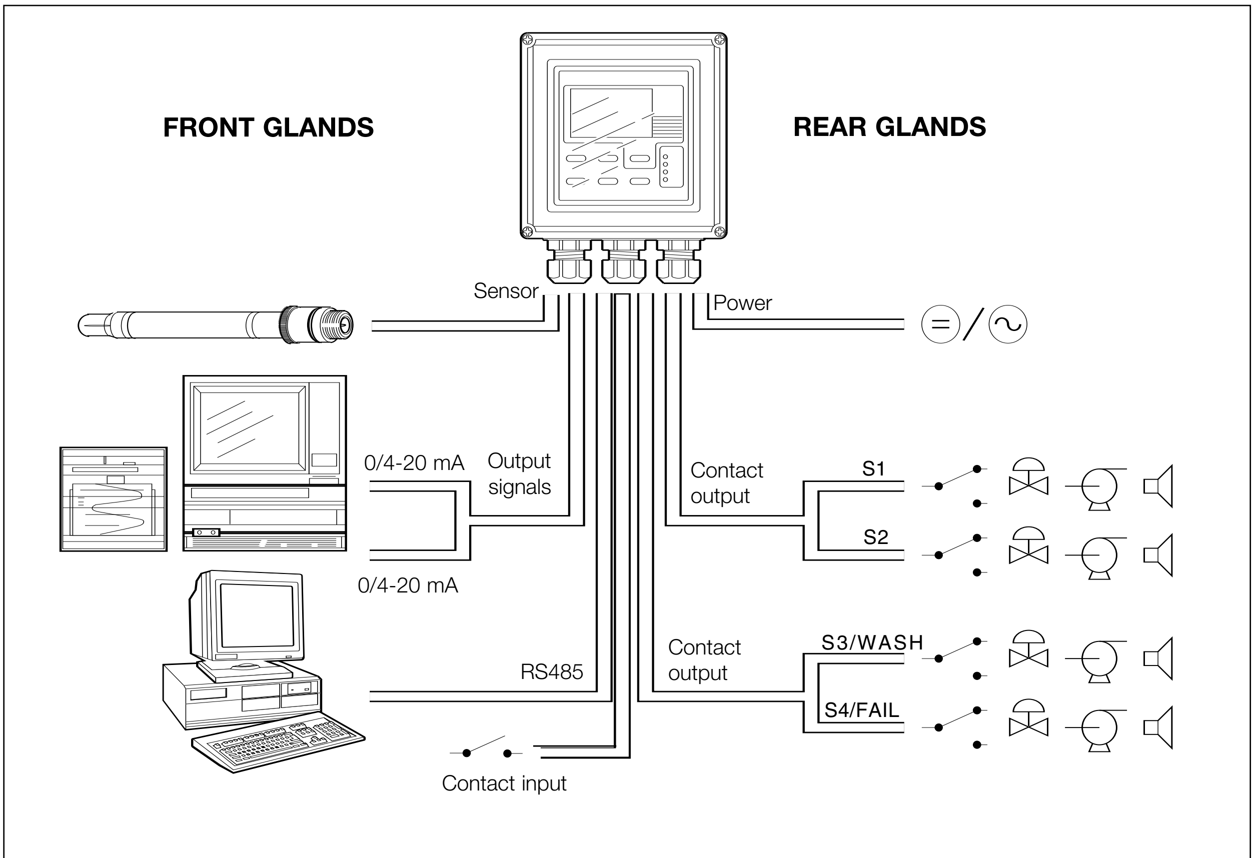


Figure 3-6. System configuration

3-3. Wiring the power supply

3-3-1. General precautions

Make sure the power supply is switched off. Also, make sure that the power supply is correct for the specifications of the EXA and that the supply agrees with the voltage specified on the nameplate. Remove the front cover by unscrewing the four screws to check this nameplate on the top of the display board.

Local health and safety regulations may require an external circuit breaker to be installed. The instrument is protected internally by a fuse. The fuse rating is dependent on the supply to the instrument. The 250 VAC fuses should be of the "time-lag" type, conforming to IEC127.

Fuse ratings are 230 VAC - 50 mA; 100 VAC - 100 mA; 115 VAC - 100 mA; 24 VDC - 1.0 A.

The internal fuse is located next to the power terminals (in the lower righthand corner).

3-3-2. Access to terminal and cable entry

Terminals 1, 2 and 3 on the bottom terminal strip are used for the power supply. Guide the power cables through the gland closest to the power supply terminals. The terminals will accept wires of 2.5 mm^2 (14 AWG). Use cable finishings if possible.

Connect the wires as indicated in the wiring diagram (refer to figure 3-6).

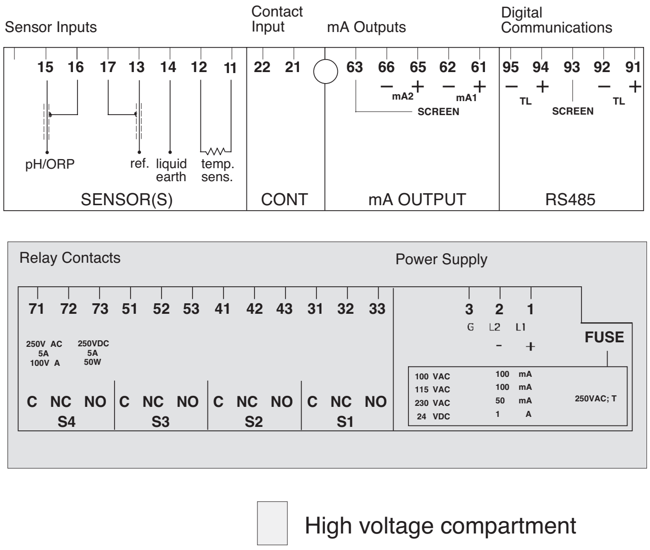


Figure 3-7. Input and output connections

3-3-3. AC power

Connect terminal 1 to the phase line of the AC power and terminal 2 to the zero line. Terminal 3 is for the power ground. This is separated from input ground by a galvanic isolation.

3-3-4. DC power

Connect terminal 1 to the positive outlet and terminal 2 to the negative outlet. Terminal 3 is for the power ground. This is separated from input ground by a galvanic isolation. A 2-core screened cable should be used with the screen connected to terminal 3. The size of conductors should be at least 1.25 mm^2. The overall cable diameter should be between 7 & 12 mm.

3-3-5. Grounding the housing

To protect the instrument against interference, the housing should be connected to ground by a large area conductor. This cable can be fixed to the rear of the housing using a braided wire cable. See figure 3-8.

3-3-6. Switching on the instrument

After all connections are made and checked, the power can be switched on from the power supply. Make sure the LCD display comes on. All segments will illuminate, then the instrument will momentarily display its unique serial number. After a brief interval, the display will change to the measured value. If errors are displayed or a valid measured value is not shown, consult the troubleshooting section (Chapter 8) before calling Yokogawa.

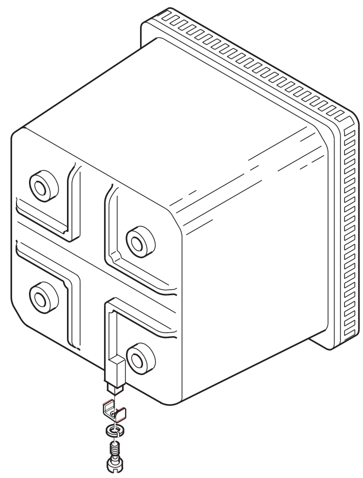


Figure 3-8. Grounding the housing

3-4. Wiring the contact signals

3-4-1. General precautions

The contact output signals consist of voltage-free relay contacts for switching electrical appliances (SPDT). They can also be used as digital outputs to signal processing equipment (such as a controller or PLC). It is possible to use multi-core cables for the contact in and output signals and shielded multi-core cable for the analog signals.

3-4-2. Contact outputs

The EXA unit's four contact outputs can be wired to suit your own custom requirements (Figure 3-6).

In the Non-Alarm or Power Off states, contacts S1, S2 and S3 are OFF, Common (C) and Normally Closed (NC) are in contact.

In the "Fail" or Power Off states, contact S4 is ON, Common (C) and Normally Closed (NC) are in contact.

You can either use them to switch AC power, or switch a DC Voltage for digital interfacing.
Default settings

- The contact S1 is pre-programmed for high alarm function.
- The contact S2 is pre-programmed for a low alarm function.
- The contact S3 is not activated as an alarm (off).
- The contact S4 is pre-programmed for FAIL.

The three control contacts (S1 to S3) can be used for simple process control by programming their function (Chapter 5). The FAIL contact is programmed to signal a fault in the measuring loop. Always connect the FAIL contact to an alarm device such as a warning light, sound annunciator, or alarm panel to make full use of the fault detection possibilities (self diagnostics) of the EXA converter.

3-5. Wiring the analog output signals

3-5-1. General precautions

The analog output signals of the EXA transmit low power standard industry signals to peripherals like control systems or strip-chart recorders (Figure 3-6).

3-5-2. Analog output signals

The output signals consist of active current signals of either 0-20 mA or 4-20 mA. The maximum load can be 600 ohms on each.

It is necessary to use screening/shielding on the output signal cables. Terminal 63 is used to connect the shielding.

3-6. Wiring the sensor system

3-6-1. Impedance measurement jumper settings

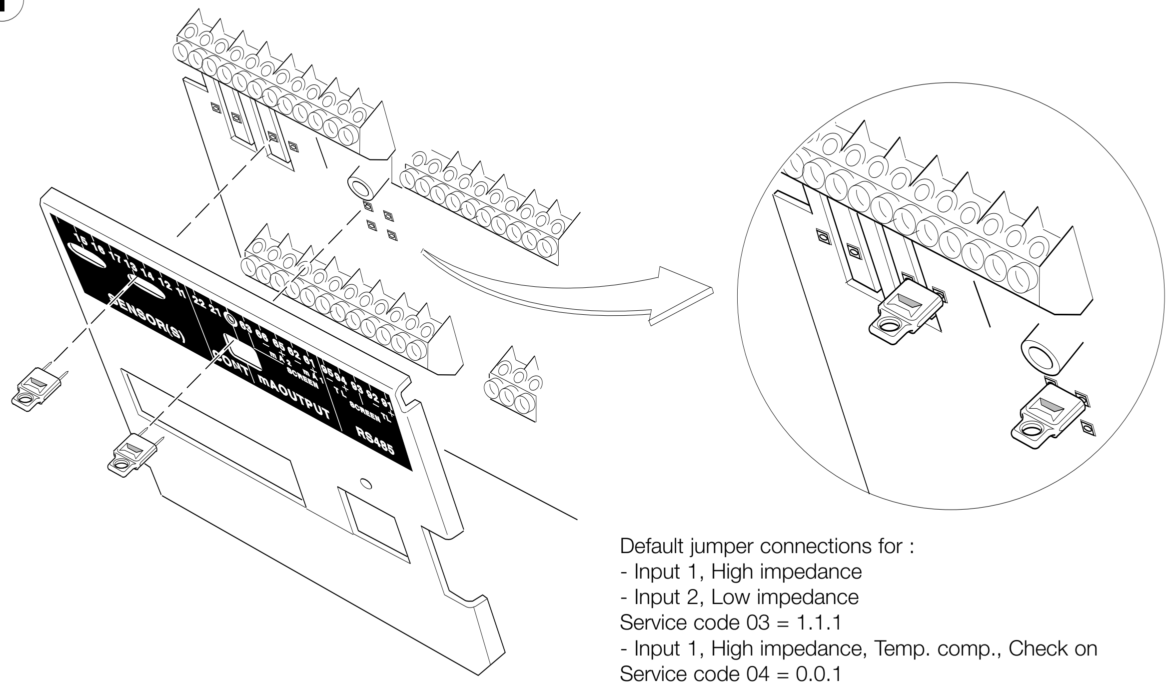
NOTE:
It is important to decide first which application and which settings are appropriate for the installation. This decision is best done before the jumpers are installed, because the cables will rest on top of the jumpers in their installed positions.

Table 3-1. Impedance measuring jumpers

Figure no.	Jumper Settings Input #1	Jumper Settings Input #2	Application & Sensor Connections
1	High Impedance	Low Impedance	Normal pH sensors Glass sensor on Input #1 Reference sensor on Input #2
2	High Impedance	High Impedance	Special electrodes using 2 glass sensors (e.g. Pfaudler 18)
3	Low Impedance	High Impedance	ORP (pH compensated) and/or rH metal sensor on Input #1 pH glass (as reference) on Input #2
4	Low Impedance	Low Impedance	ORP (Redox measurement) metal sensor on Input #1 Normal reference on Input #2

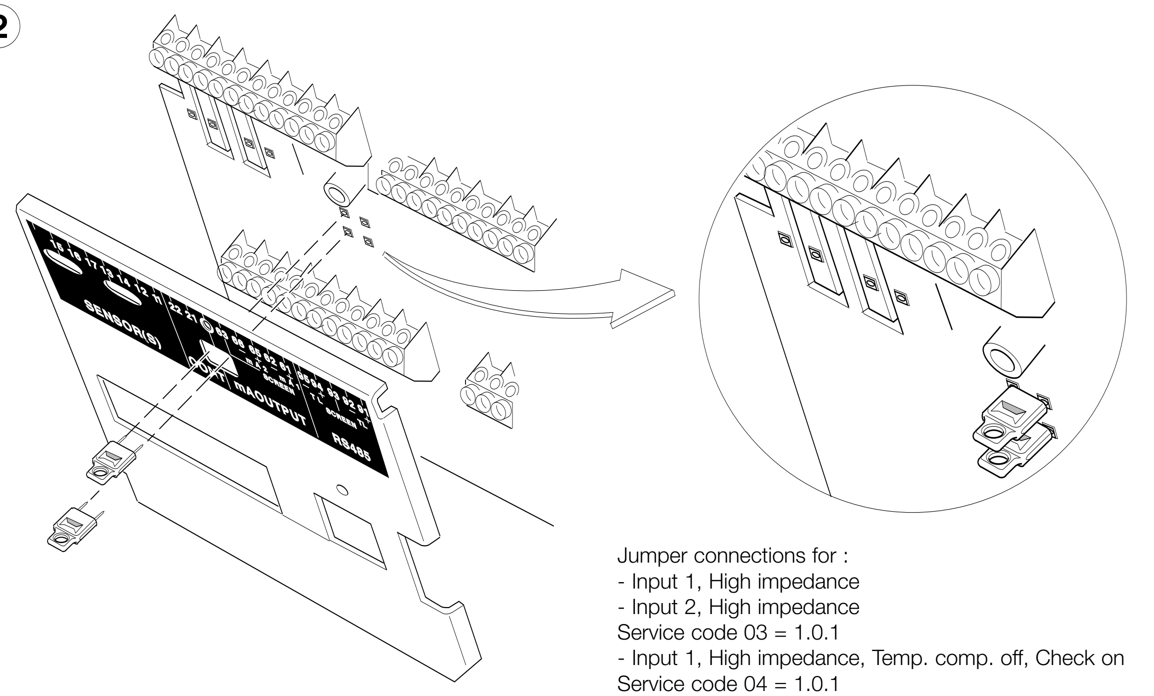
The following four jumper figure illustrations (figure 3-9) show the jumper positions related to the figure numbers in the above table.

1



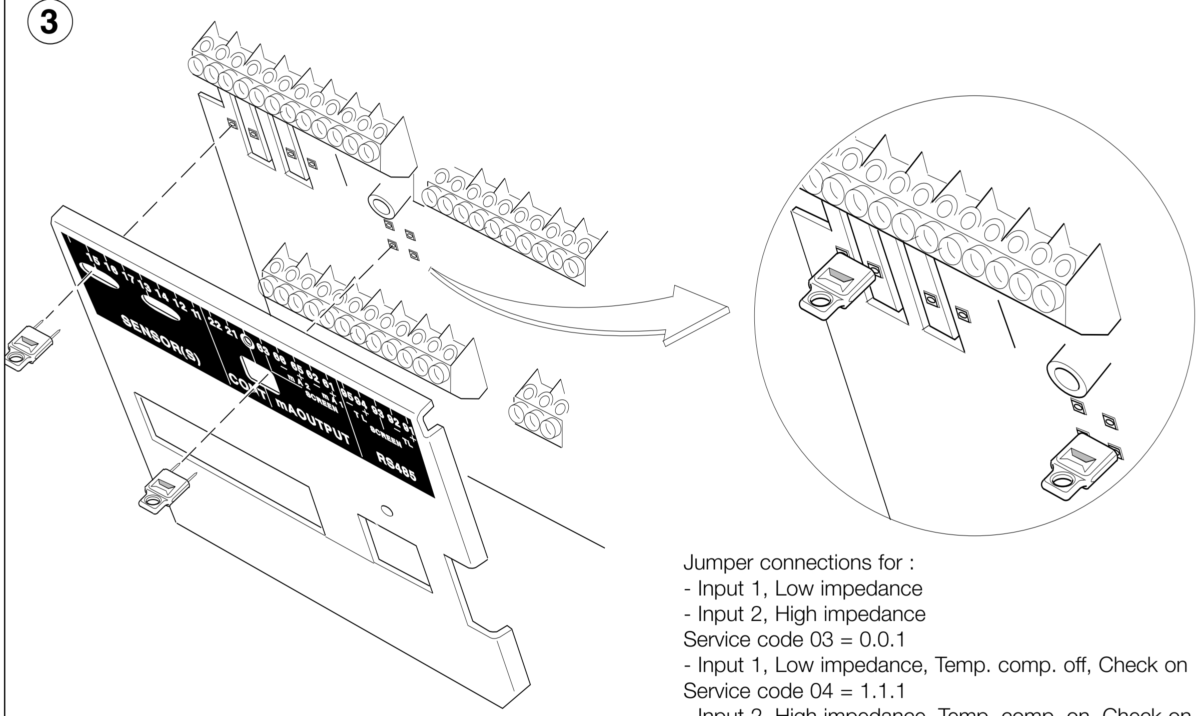
Default jumper connections for :
- Input 1, High impedance
- Input 2, Low impedance
Service code 03 = 1.1.1
- Input 1, High impedance, Temp. comp., Check on
Service code 04 = 0.0.1
- Input 2, Low impedance, Temp. comp. off, Check on

2



Jumper connections for :
- Input 1, High impedance
- Input 2, High impedance
Service code 03 = 1.0.1
- Input 1, High impedance, Temp. comp. off, Check on
Service code 04 = 1.0.1
- Input 2, Low impedance, Temp. comp. off, Check on

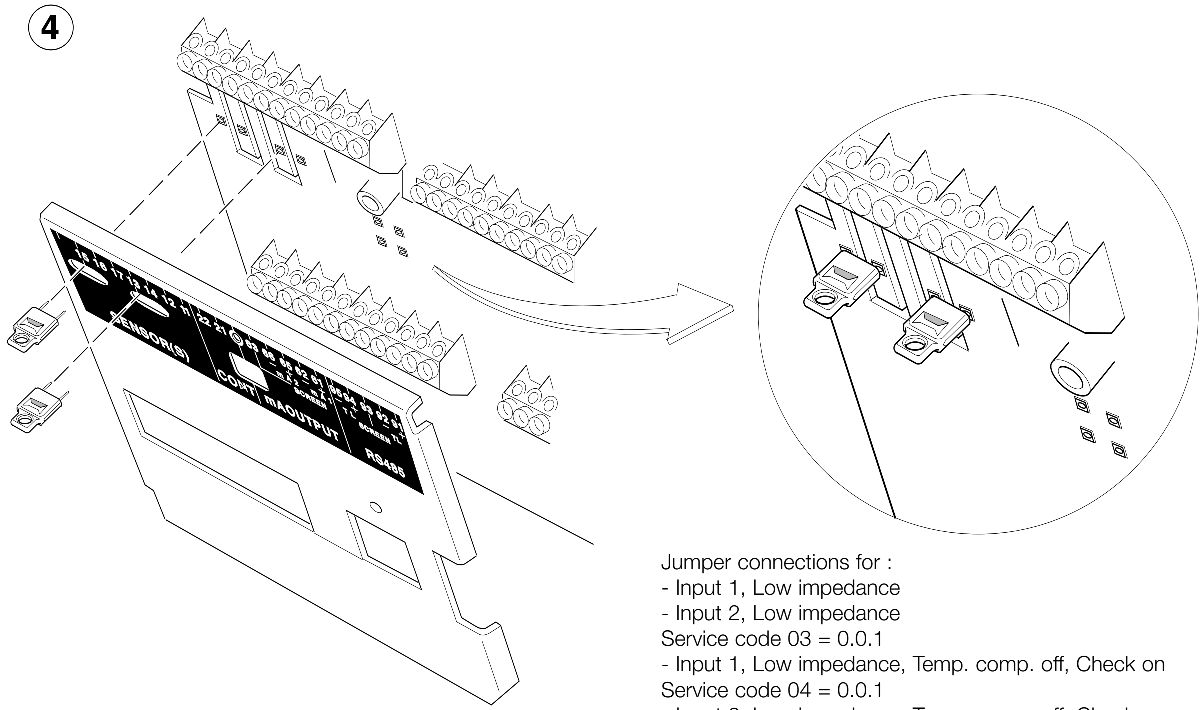
Figure 3-9a. Impedance measurement jumper setting



Jumper connections for :
- Input 1, Low impedance
- Input 2, High impedance

Service code 03 = 0.0.1
- Input 1, Low impedance, Temp. comp. off, Check on

Service code 04 = 1.1.1
- Input 2, High impedance, Temp. comp. on, Check on



Jumper connections for :
- Input 1, Low impedance
- Input 2, Low impedance

Service code 03 = 0.0.1
- Input 1, Low impedance, Temp. comp. off, Check on

Service code 04 = 0.0.1
- Input 2, Low impedance, Temp. comp. off, Check on

Figure 3-9b. Impedance measurement jumper setting

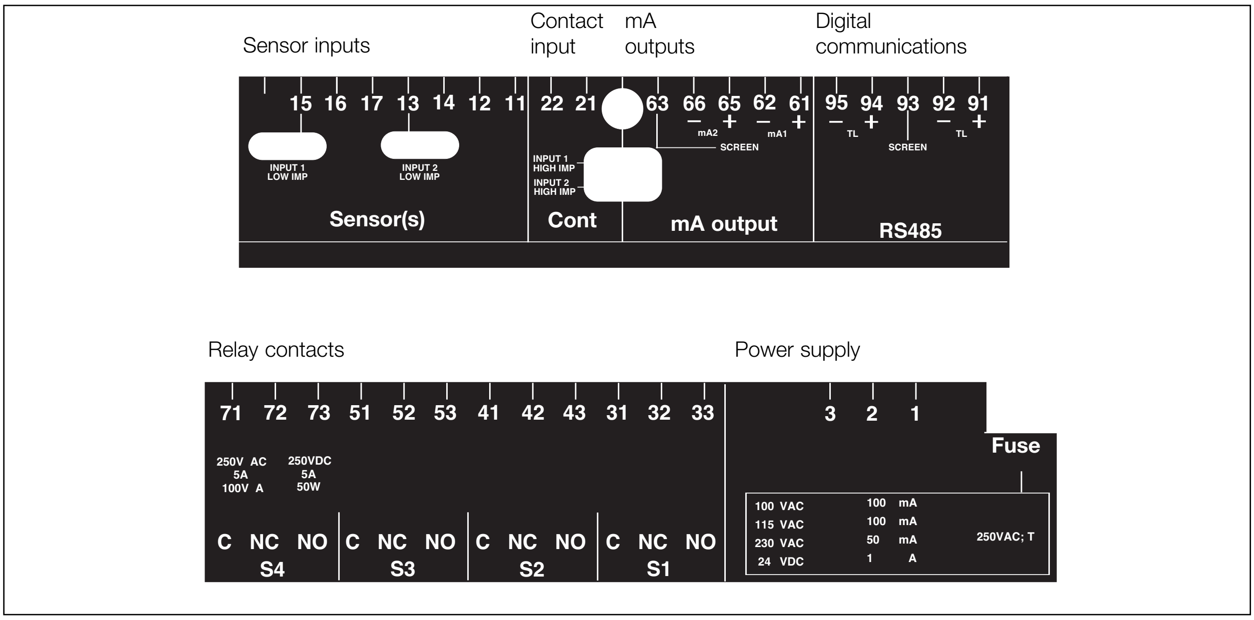


Figure 3-10. Terminal identification labels

3-7. Sensor wiring

Refer to figure 3-11, which includes drawings that outline sensor wiring.

The EXA PH402 can be used with a wide range of commercially available sensor types, both from Yokogawa and other manufacturers. The sensor systems from Yokogawa fall into two categories; the ones that use a fixed cable and the ones with separate cables.

To connect sensors with fixed cables, simply match the terminal numbers in the instrument with the identification numbers in the instrument on the cable ends.

The separate sensors and cables are not numbered, but instead use a color-coding system. The electrodes have a colored band incorporated in the label on the connection cap:

- **Red** for measuring electrodes (both pH and ORP)
- **Yellow** for reference electrodes
- **Blue** for combined sensors with both measuring and reference elements in the same body
- **Green** for temperature sensors

The recommended procedure is to color-code each end of the cables to match the sensors with the color strips provided with each cable. This provides a quick way to identify the ends of the cables belonging to a particular sensor when they are installed. (The procedure for fixing the identification labels is described in detail in the instruction sheet provided with the cable.)

3-7-1. Connection cable

There are two types of connection cable, one for single sensors and one for combined sensors. The former is a coaxial cable and has only two connections.

- Red to measuring element
- Blue to screen (shield)

The latter is a triaxial cable with three connections, (it has an extra white wire termination) these wires are connected:

- Red to measuring element
- Blue to reference
- White to screen (shield)

To connect the other sensor systems, follow the general pattern of the terminal connections as listed below:

11 & 12	Temperature compensation resistor input (Pt100, Pt1000, 3k, 5k1, 8k55 and 10k PTC)
13	Input no. 2 (normally the reference element)
17	Screen (shield) for input no. 2
14	Liquid earth (solution ground) connection
15	Input no. 1 (normally the measuring element)
16	Screen (shield) for input no. 1

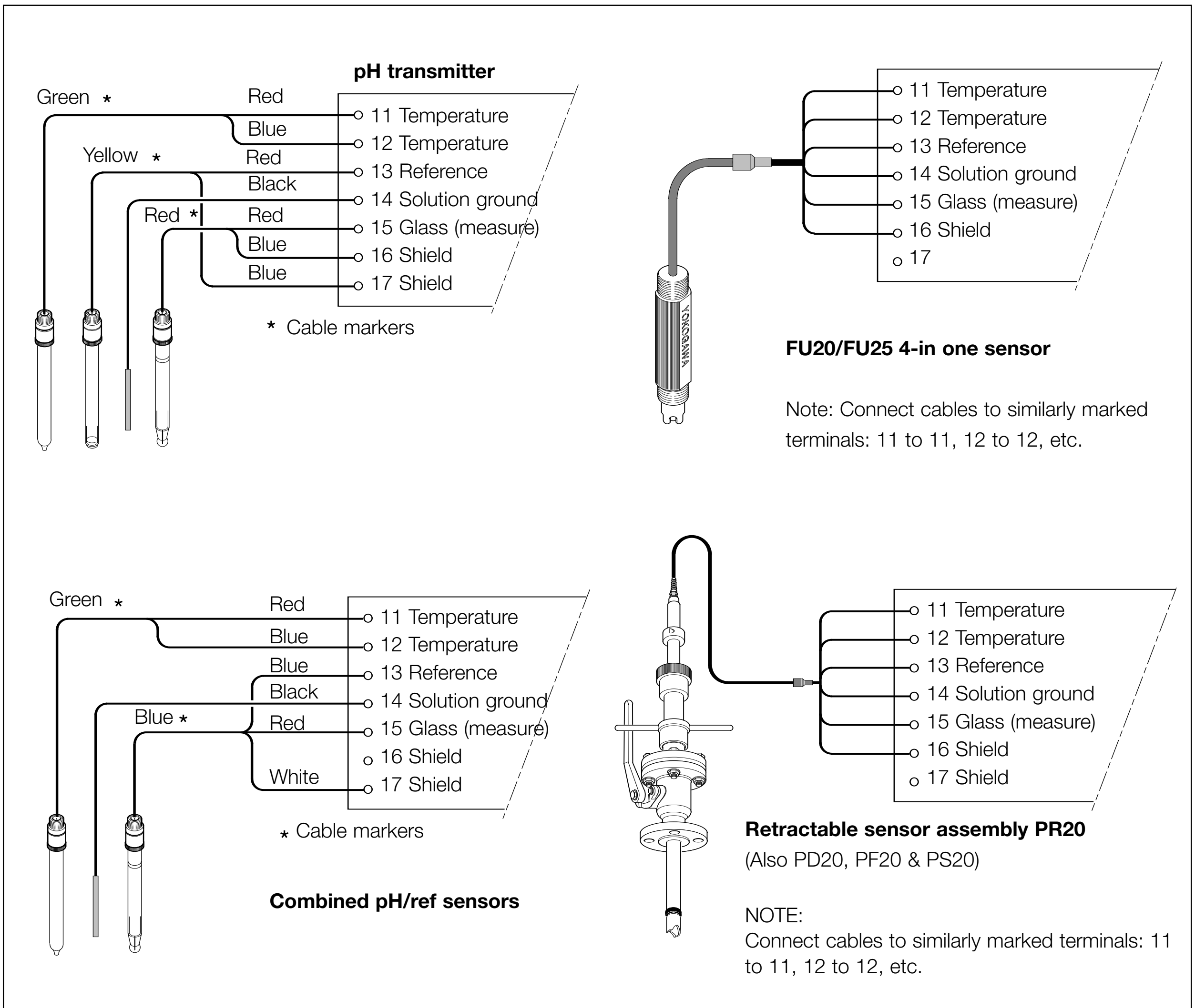


Figure 3-11a. Sensor wiring

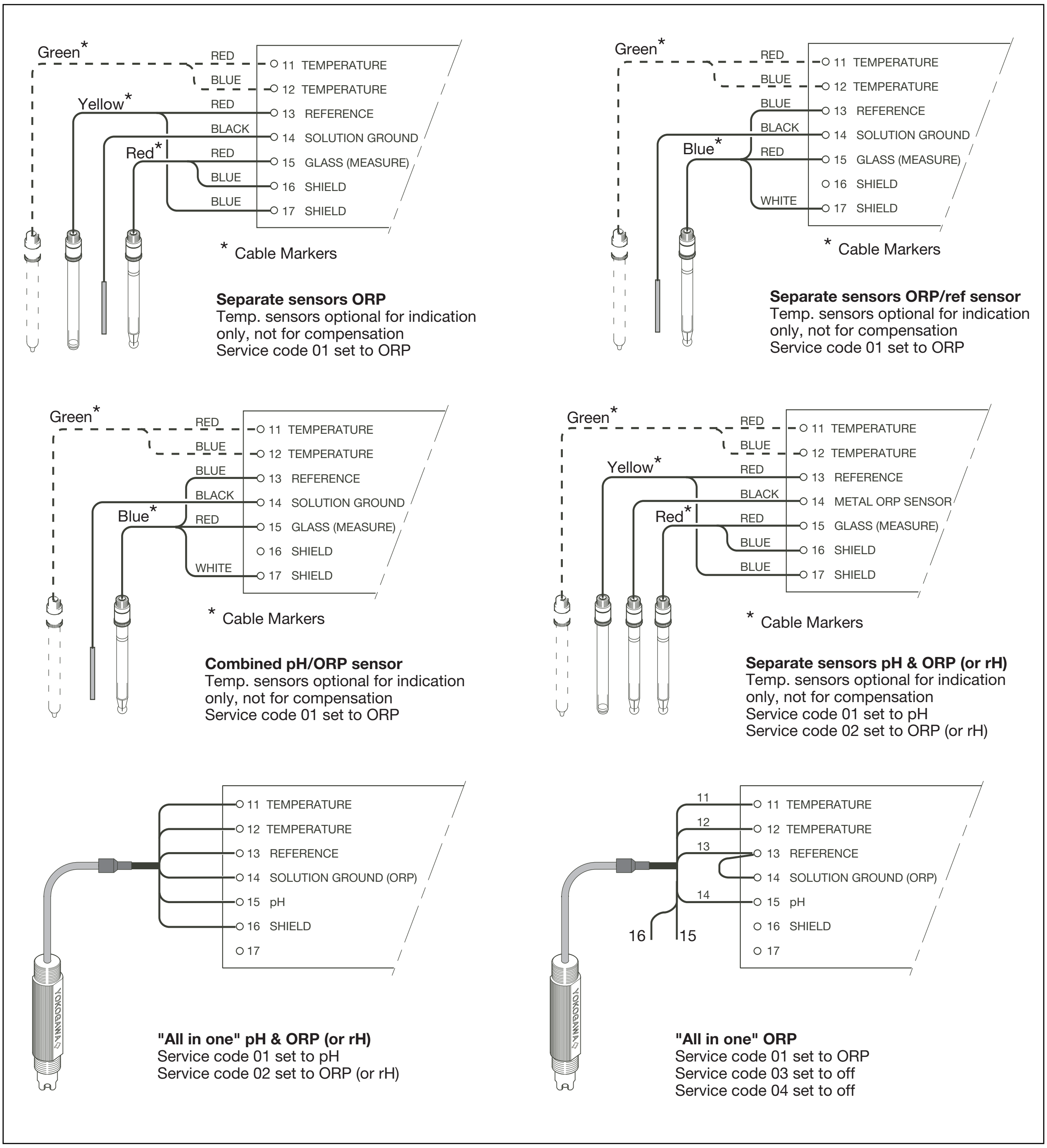
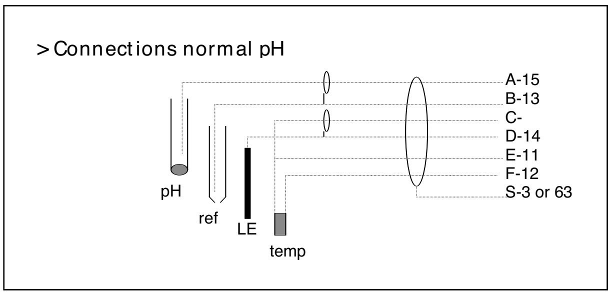
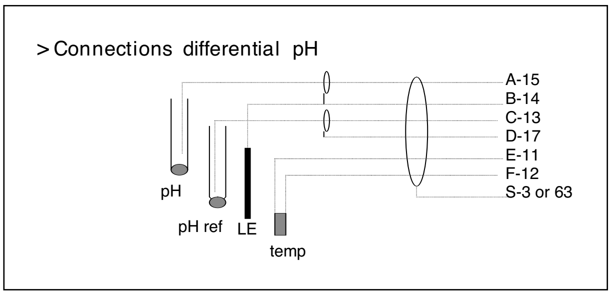


Figure 3-11b. Sensor wiring





3-7-2. Sensor cable connection with special grommet

In order to seal multiple sensor cables into EXA PH402, a special grommet is provided that is designed to accommodate one, two or three sensor cables (5 mm dia.) plus a liquid earth cable (2.5 mm dia.). In the pack with the grommet are blanking pieces to close any unused holes. When correctly assembled, the grommet maintains the IP65 (NEMA 4X) rating of the EXA PH402 housing.

Refer to figure 3-12 to assemble the grommet connections:

1. First remove the nut and standard rubber seal from the selected gland
2. Discard the seal. This will be replaced later by the special grommet
3. Thread the cables through the nut and the gland
4. Connect the cables to their designated terminals
5. Arrange the cables to avoid tangles and insert the grommet between the gland and the nut
6. The grommet is split to permit the cables to be mounted after connection.
   (This also ensures even length adjustment.)
7. Ensure that any unused holes are filled with the blanking pieces
8. Tighten the nut to form a firm seal. (Hand-tight is sufficient.)

Note: The special gland is intended to be used to seal the multiple cables from the Yokogawa flow fittings such as FF20 and FP20. The designated cables are WU20 sensor cables, which are approximately 5 mm (0.2 “) in diameter, and 82895002 liquid earth cables, which are approximately 2.5 mm (0.1 “) in diameter.

For sensor systems using a single cable, like the FU20 (FU25) and the PR20, PD20, PF20 and PS20, the standard gland will accommodate the cable adequately. Single cables between approximately 7 mm and 12 mm (0.28 “ and 0.47 “) can be sealed properly with these glands.

3-7-3. Sensor cable connections using junction box (BA10) and extension cable (WF10)

Where a convenient installation is not possible using the standard cables between sensors and converter, a junction box and extension cable may be used. The Yokogawa BA10 junction box and the WF10 extension cable should be used. These items are manufactured to a very high standard and are necessary to ensure that the specifications of the system can be met. The total cable length should not exceed 50 metres (e.g. 5 m fixed cable and 45 m extension cable). In the case of systems using dual high impedance sensors (e.g. Pfaudler 18), then the cable length is restricted to 20 metres (fixed cable only, no extension with F10).

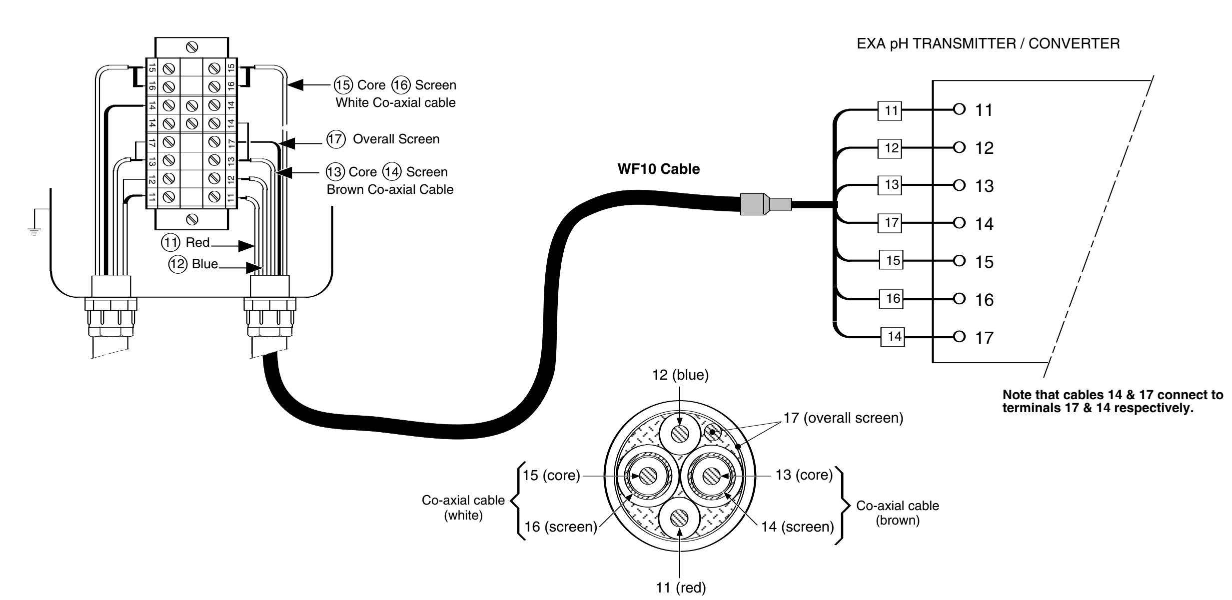


Fig. 3-12. Connection of WF10 extension cable and BA10/BP10 junction box

Extension cable may be purchased in bulk quantities or in pre-finished lengths. In the case of bulk quantities cut to length, then it is necessary to terminate the cable as shown below.

Termination procedure for WF10 cable.

1. Slide 3 cm of heat shrink tube (9 x 1.5) over the cable end to be terminated.
2. Strip 9 cm of the outer (black) insulating material, taking care not to cut or damage internal cores.

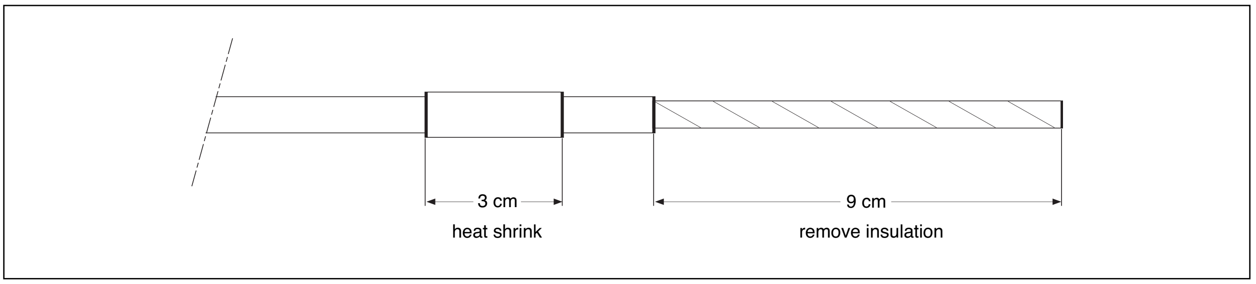


Fig. 3-13a.

3. Remove loose copper screening, and cut off the cotton packing threads as short as possible.
4. Strip insulation from the last 3 cm of the brown, and the white coaxial cores.

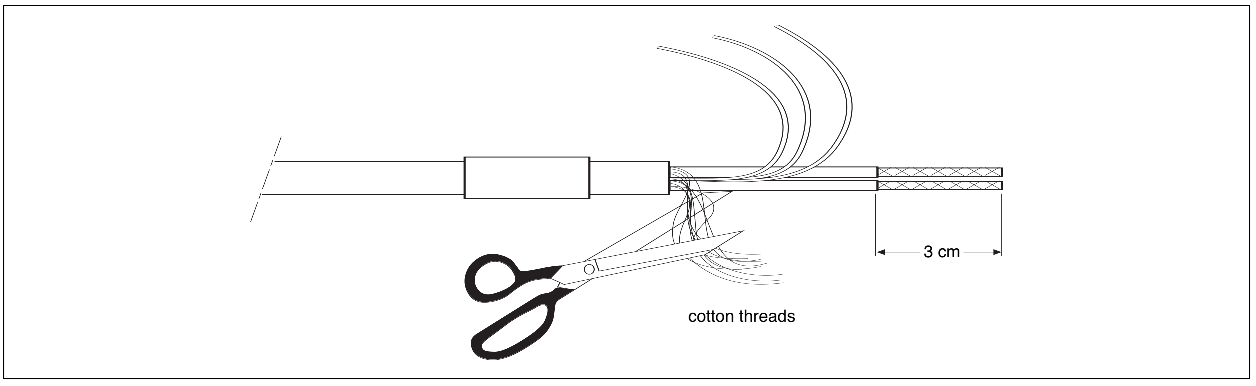


Fig. 3-13b.

5. Extract the coaxial cores from the braid, and trim off the black (low-noise) screening material as short as possible.
6. Insulate the overall screen and the 2 coaxial screens with suitable plastic tubing.
7. Strip and terminate all ends with suitable (crimp) terminals and identify with numbers as shown.

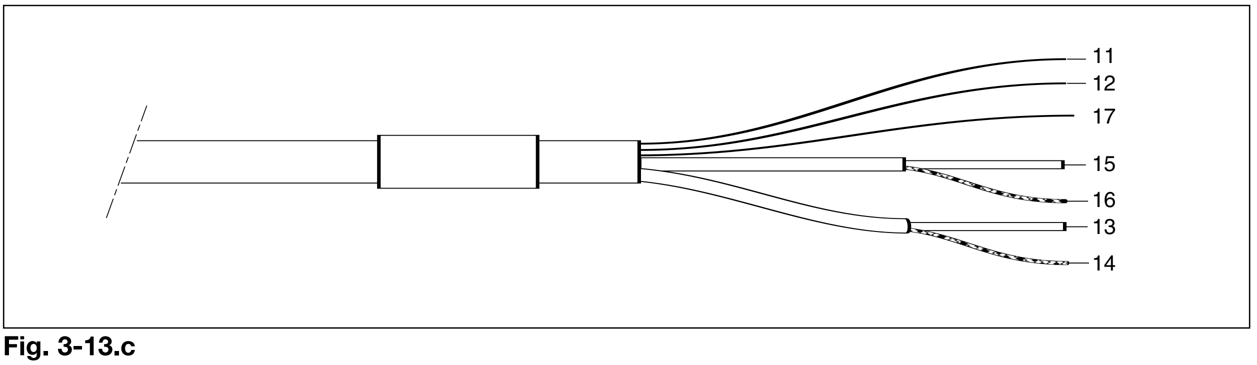


Fig. 3-13.c

8. Finally shrink the overall heat shrink tube into position.

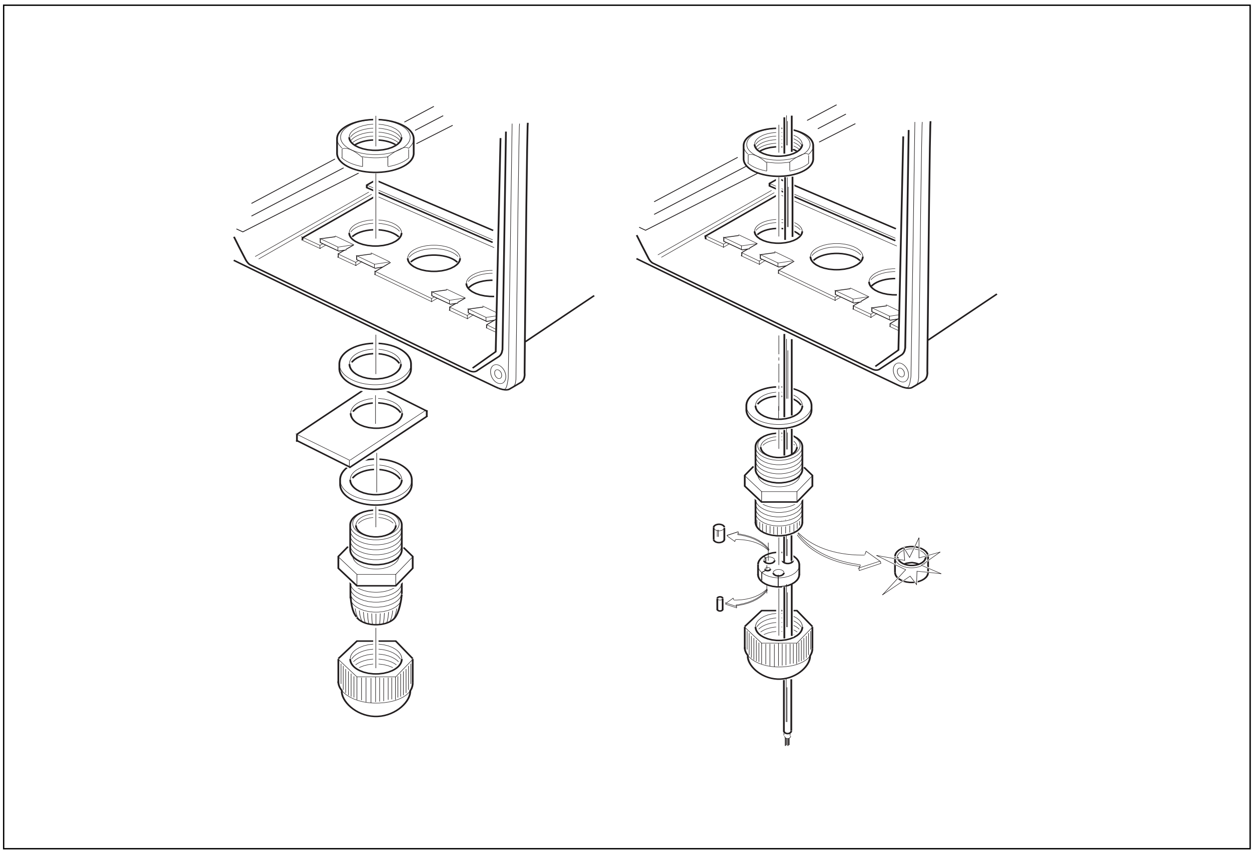


Figure 3-14. Sensor cable connections with special grommet

3-8. Tag plate mounting

When option /SCT is specified, a stainless steel tagplate is supplied with the designated Tag No. stamped or engraved. It is mounted as shown in figure 3-14 using one of the cable glands.

4. OPERATION; DISPLAY FUNCTIONS AND SETTING

4-1. Operator interface

This section provides an overview of the operation of the EXA operator interface. The basic procedures for obtaining access to the three levels of operation are described briefly. For a step-by-step guide to data entry, refer to the relevant section of this instruction manual. Figure 4-1 shows the EXA operator interface.

LEVEL 1: Maintenance

These functions are accessible by pushbutton through a flexible front cover window. The functions make up the normal day-to-day operations that an operator may be required to complete. Adjustment of the display and routine calibration are among the features accessible in this way. (See table 4-1).

LEVEL 2: Commissioning

A second menu is exposed when the EXA front cover is removed and the display board is revealed. Users gain access to this menu by pressing the button marked * in the lower right of the display board. This menu is used to set such values as the output ranges and hold and wash features. It also gives access to the service menu. (See table 4-1).

LEVEL 3: Service

For more advanced configuration selections, press the button marked * , then press “NO” repeatedly until you reach SERVICE. Now push the “YES” button. Selecting and entering “Service Code” numbers in the commissioning menu provide access to the more advanced functions. An explanation of the Service Codes is listed in chapter 5 and an overview table is shown in chapter 10.

Table 4-1. Operations overview

	Routine	Function	Chapter
Maintenance	AUT CAL	Calibration with programmed buffer solutions	6
	MAN CAL	Calibration with other buffer solutions	6
	SAMPLE	Grab sample calibration	6
	DISPLAY	Read auxiliary data or set message display	4
	SETPOINTS	Adjust alarm setpoints (when activated)	5
	WASH	Manual wash start (when activated)	5
	MAN.IMP	Manual start of impedance check	5
	TEMPERATURE	Select automatic or manual compensation	5
	HOLD	Switch hold on/off (when activated)	5
Commissioning	SETPOINTS	Adjust alarm setpoints	5
	RANGE	Adjust the output range	5
	SET HOLD	Activate the hold function	5
	WASH	Activate and configure the wash timer	5
Service (Access to coded entries from the commissioning level)	SERVICE	Fine tune the specialized functions of the converter	5

NOTE:
All three levels may be separately protected by a password. See Service Code 52 in chapter 5 Service Code table for details on setting passwords.

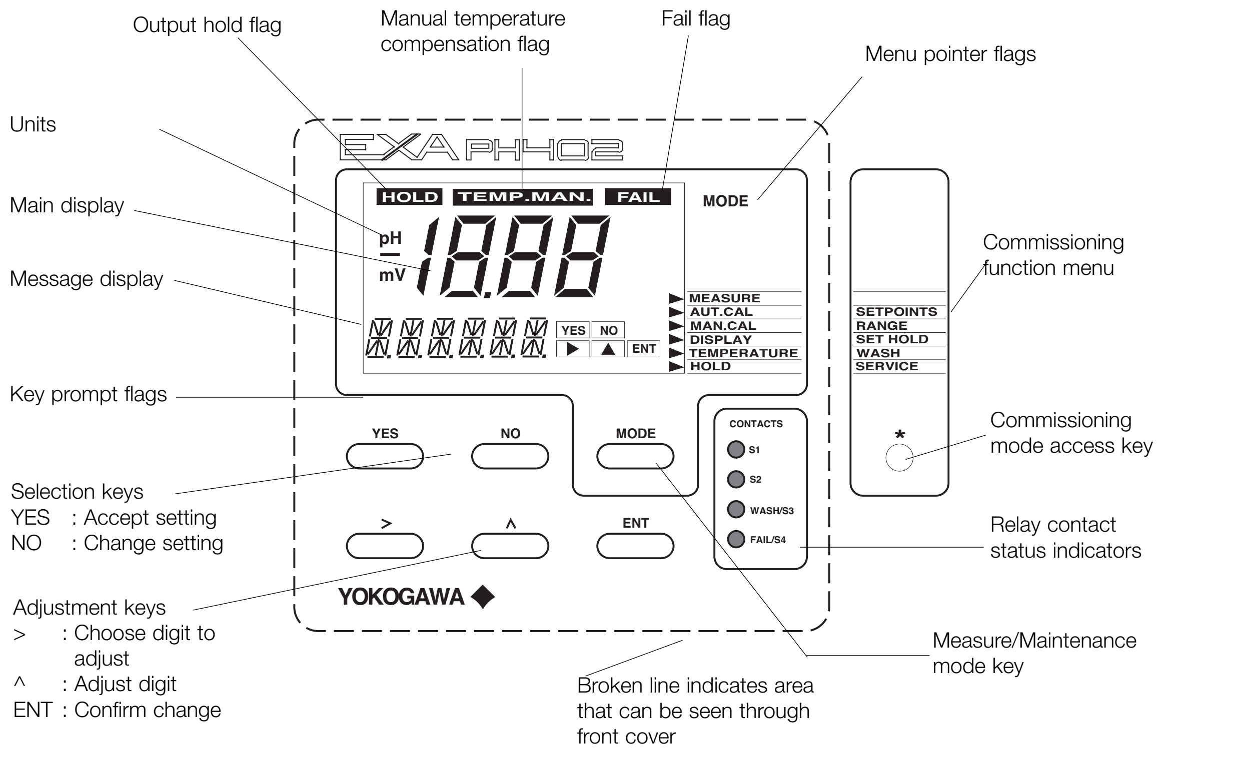


Figure 4-1. PH402 operator interface

4-2. Explanation of operating keys

MODE key This key toggles between the measuring and maintenance modes. Press once to obtain access to the maintenance function menu.

AUTO CAL
MAN CAL
DISPLAY
SETPOINT
WASH
MAN.IMP
TEMPERATURE
HOLD

Press again to return to the measuring mode (press twice when hold is activated).

YES/NO keys These are used to select choices from the menu.
YES is used to accept a menu selection.
NO is used to reject a selection, or to move ahead to the next option.

DATA ENTRY keys (▶ ▲ ENT)

▶ is used as a “cursor” key. Each press on this key moves the cursor or flashing digit one place to the right. This is used to select the digit to be changed when entering numerical data.

▲ is used to change the value of a selected digit. Each press on this key increases the value by one unit.The value can not be decreased, so in order to obtain a lower value, increase past nine to zero, then increase to the required number.

ENT When the required value has been set using the > & ^ keys, press ENT to confirm the data entry. Please note that the EXA 402 does not register any change of data until the ENT key is pressed.

*** key** This is the commissioning mode key. It is used to obtain access to the commissioning menu. This can only be done with the cover removed or opened. Once this button has been used to initiate the commissioning menu, follow the prompts and use the other keys as described above.

4-3. Setting passcodes

4-3-1. Passcode protection

In Service Code 52, EXA users can set passcode protection for each one of the three operating levels, or for any one or two of the three levels. This procedure should be completed after the initial commissioning (setup) of the instrument. The passcodes should then be recorded safely for future reference.

When passcodes have been set, the following additional steps are introduced to the configuration and programming operations:

Maintenance
Press MODE key. The display shows 000 and *PASS*
Enter a 3-digit passcode as set in Service Code 52 to obtain access to the Maintenance Mode

Commissioning
Press * key. The display shows 000 and *PASS*
Enter a 3-digit passcode as set in Service Code 52 to obtain access to the Commissioning Mode.

Service
From the commissioning menu, select *Service by pressing YES key. The display shows 000 and *PASS*
Enter a 3-digit passcode as set in Service Code 52 to obtain access to the Service Mode.

NOTE:
See Service Code 52 for the setting of passcodes.

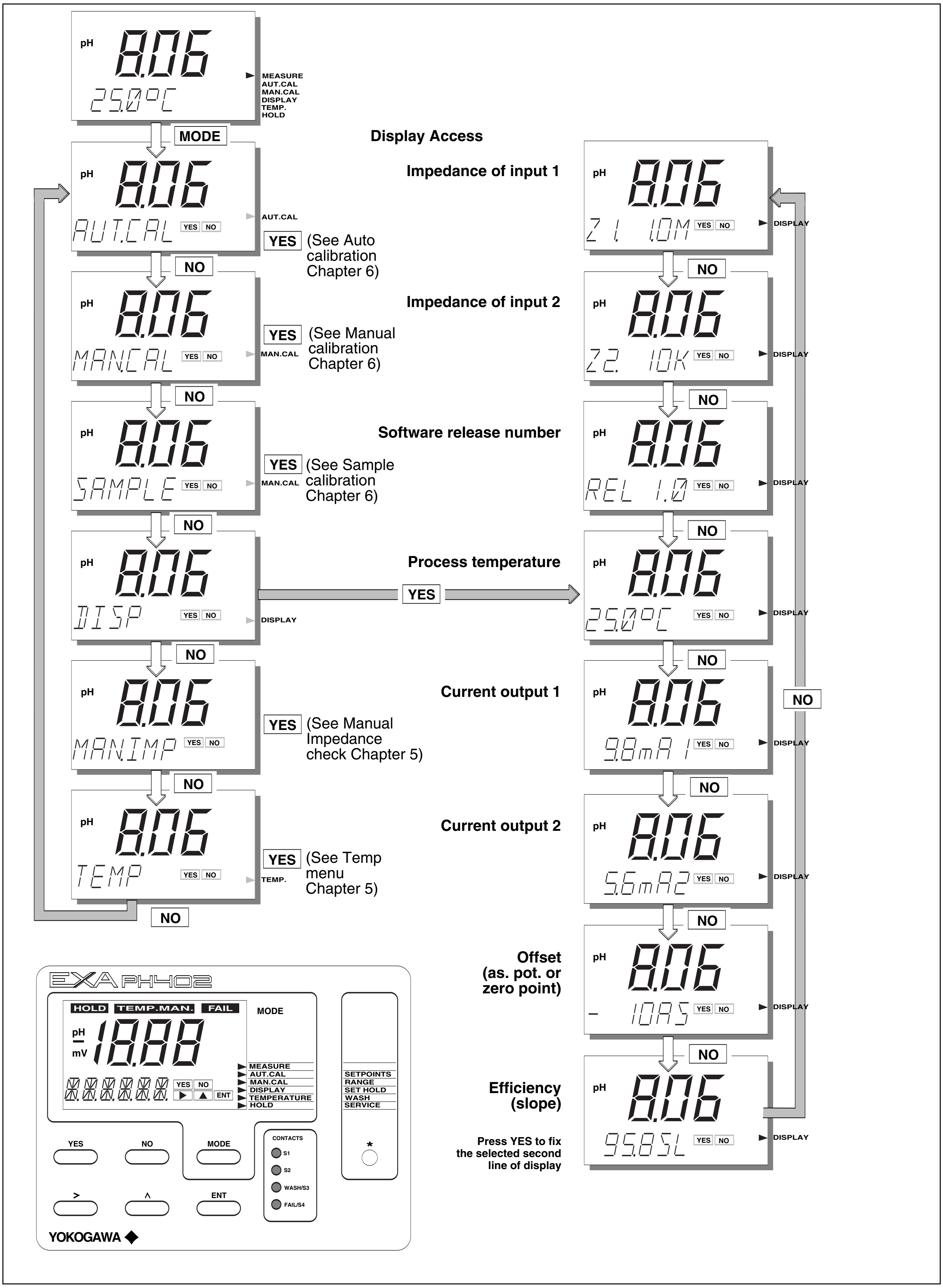
4-4. Display examples

The following pages show the sequence of button presses and screens displayed when working in some standard configurations.

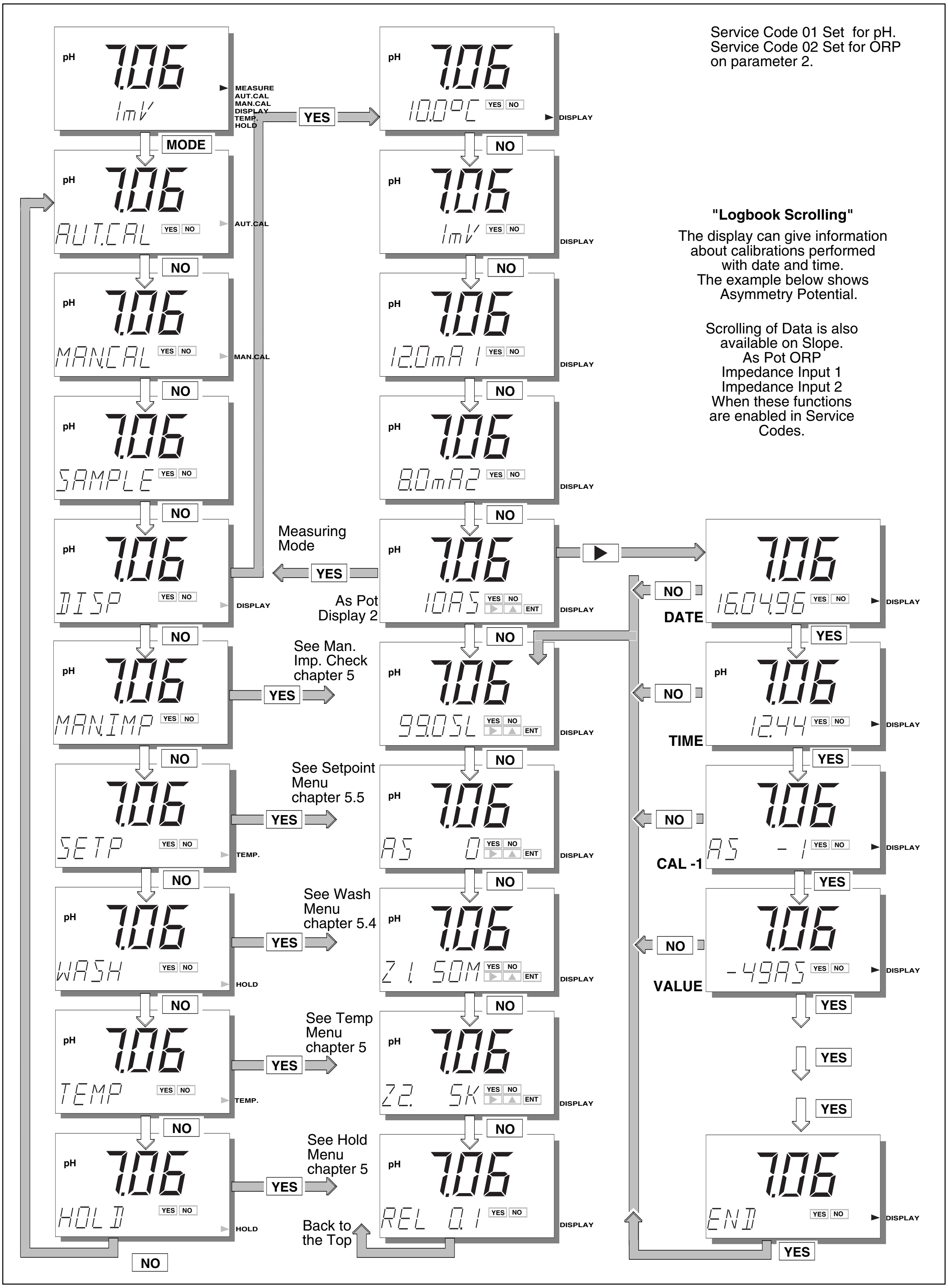
More or less options will be made available by the configuration of some service codes. For instance the impedance measurement screens do not appear when impedance checking is switched off in service codes 03 and 04.

4-5. Display functions

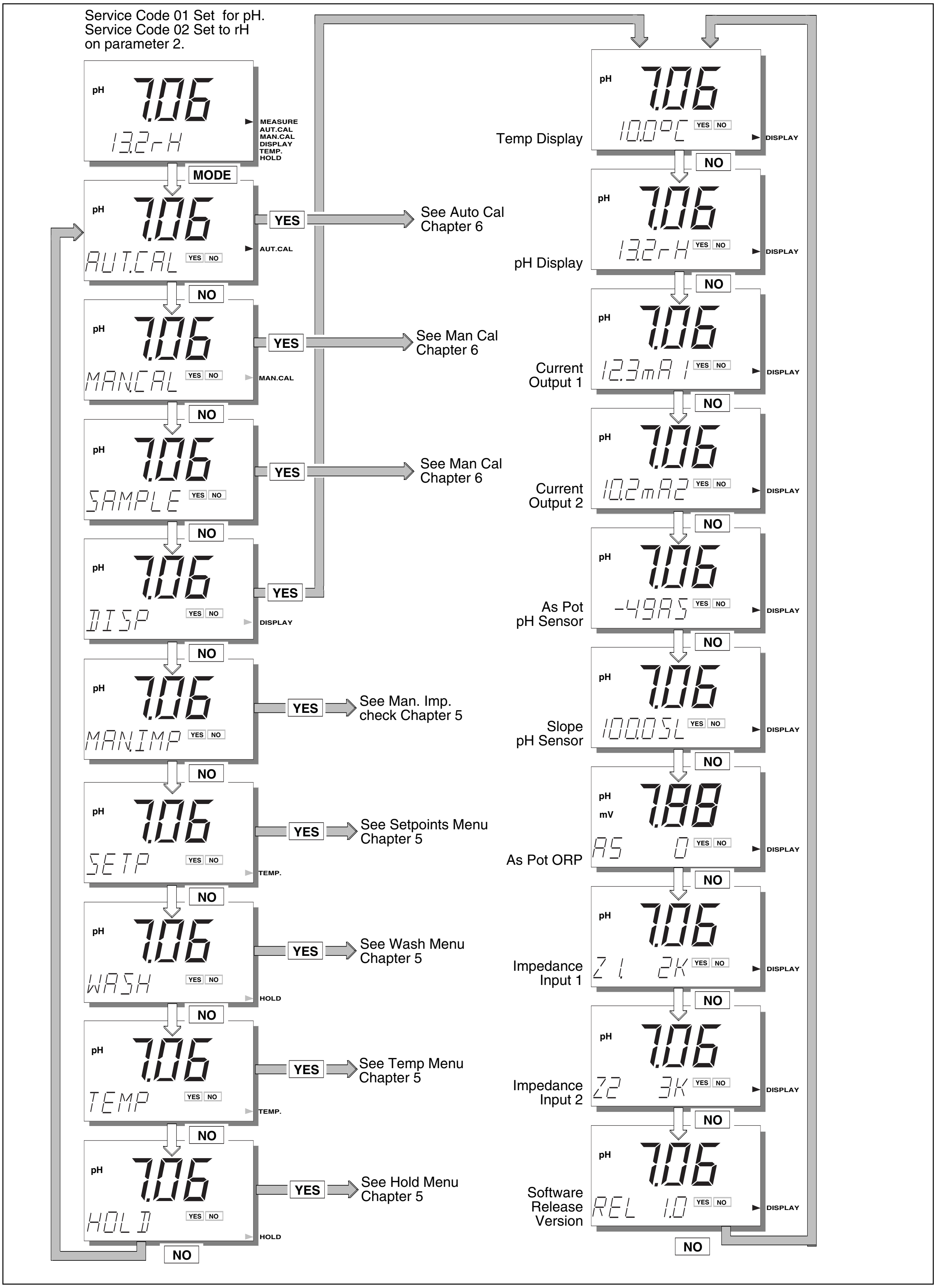
4-5-1. Display functions pH (default)



4-5-2. Display functions pH (ORP)



4-5-3. Display functions pH (rH)



5. PARAMETER SETTING

5-1. Maintenance mode

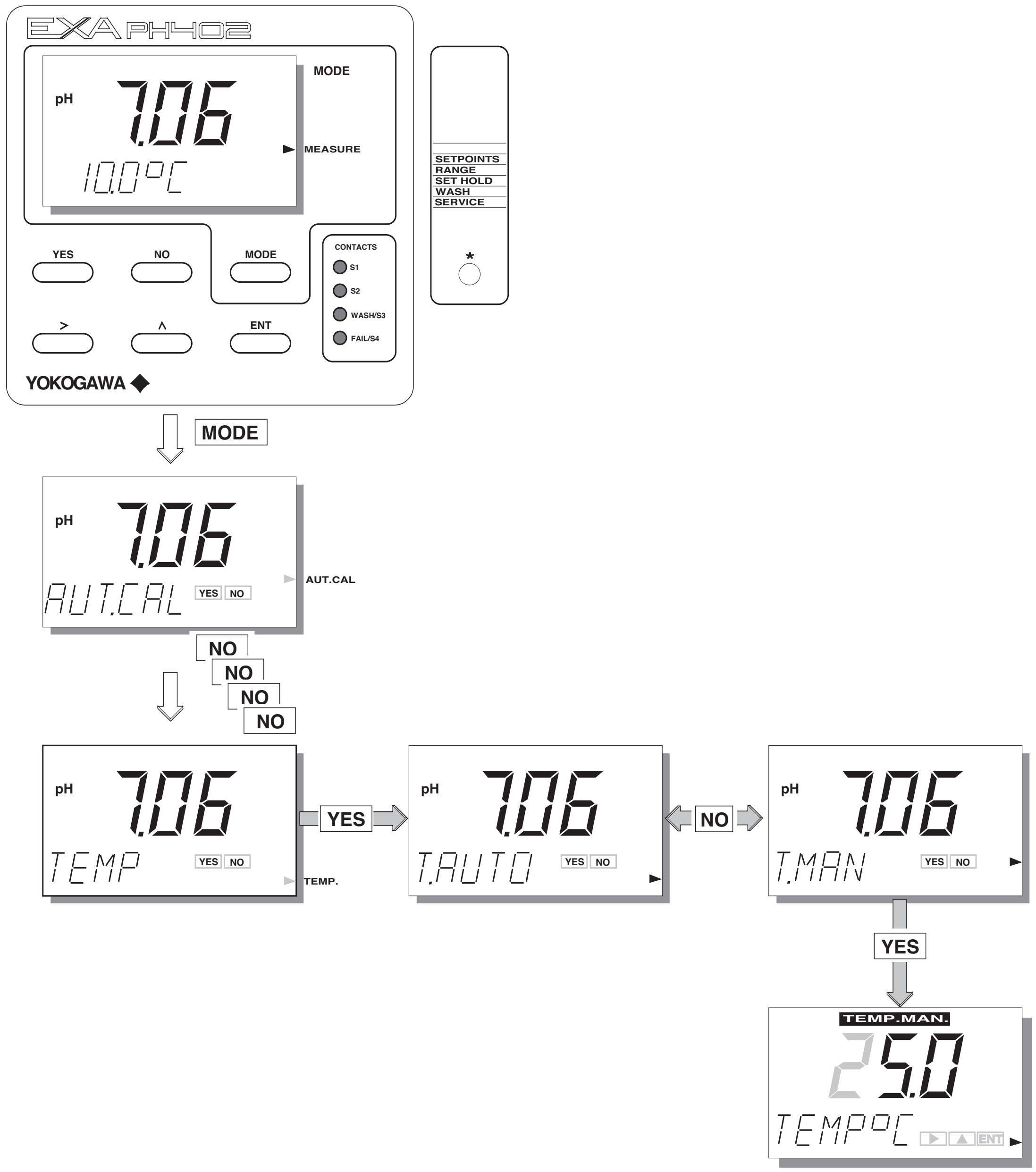
Standard operation of the EXA instrument involves use of the maintenance (or operating) mode to set up some of the parameters.

Access to the maintenance mode is available via the six keys that can be pressed through the flexible window in the instrument cover. Press the MODE-key once to enter this dialog mode.
NOTE:
At this stage the user will be prompted for pass code where this has been previously set up in service code 52 in chapter 5.

Automatic calibration	See “calibration” section 6.
Manual calibration	See “calibration” section 6.
Sample calibration	See “calibration” section 6.
Display setting	See “operation” section 4.
Manual impedance check	See “operation” section 5.
Setpoint	Select and adjust setpoint (when enabled in service menu section 5, service code 51). See adjustment procedure in §5-1-5 and §5-2-1.
Wash	Manually start/stop wash cleaning (when enabled in service menu section 5, service code 51). See adjustment procedure in §5-1-4 and §5-2-4.
Temperature	Set automatic or manual compensation and adjust manual reading (when pH is set in section 5 service code 01). See adjustment procedure in §5-1-1.
Hold	Manually switch on/off HOLD (when enabled in commissioning menu section). See adjustment procedure in §5-2-3..

5-1-1. Manual temperature selection and adjustment

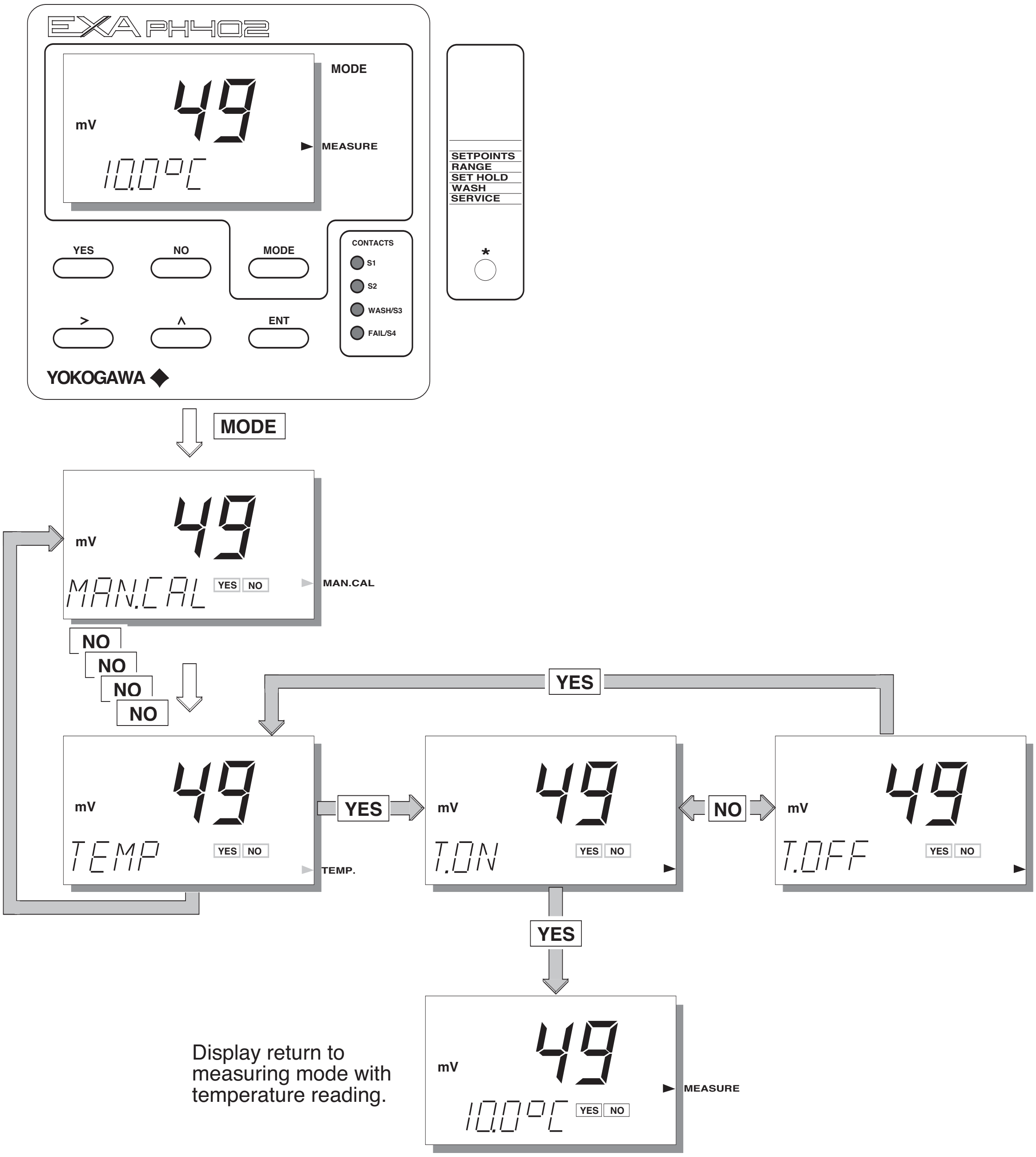
pH selected in service code 01.



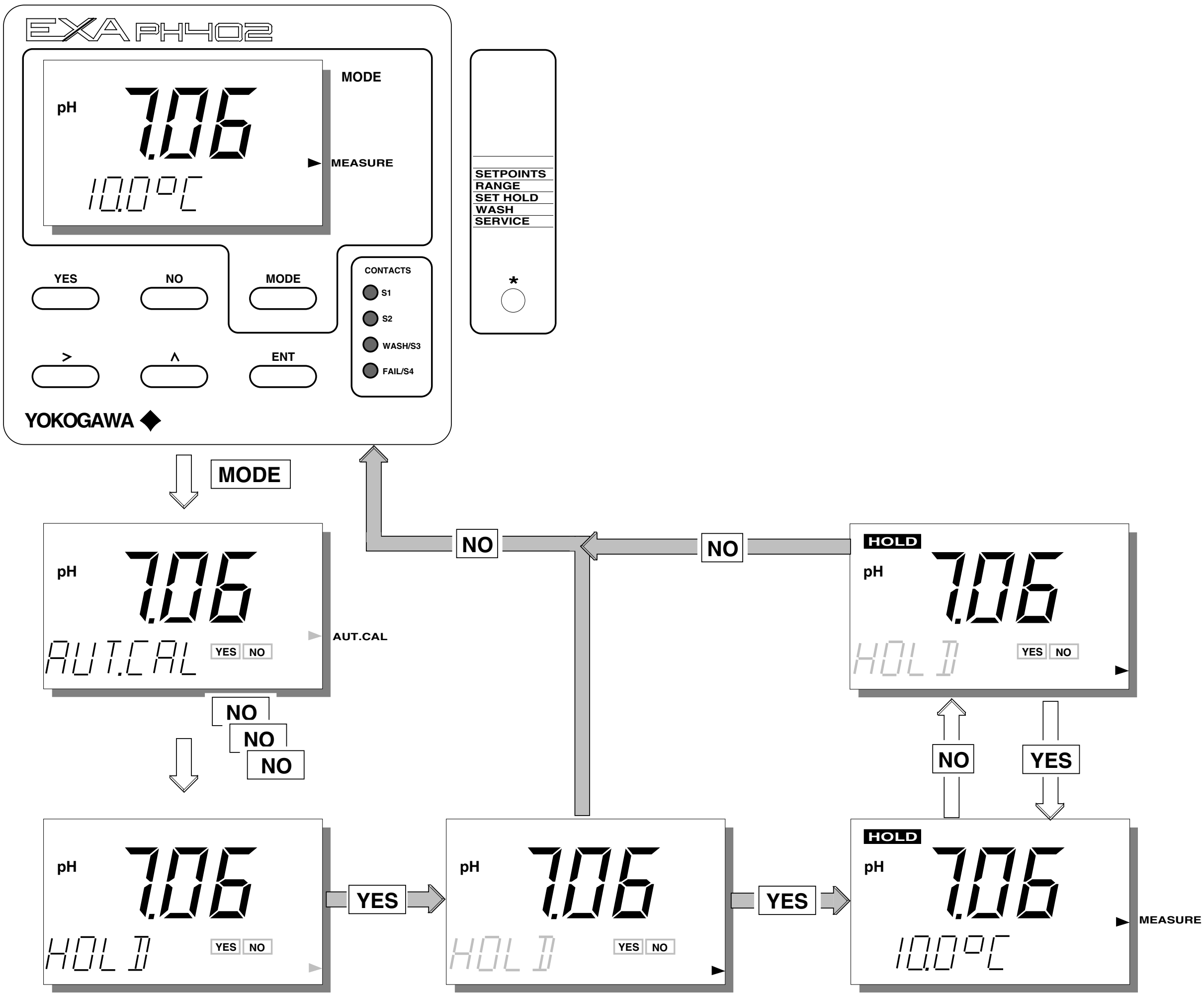
Use ▶ ▲ ENT keys to adjust and enter manual temperature setting

5-1-2. Process temperature measuring in ORP mode

ORP selected in service code 01.

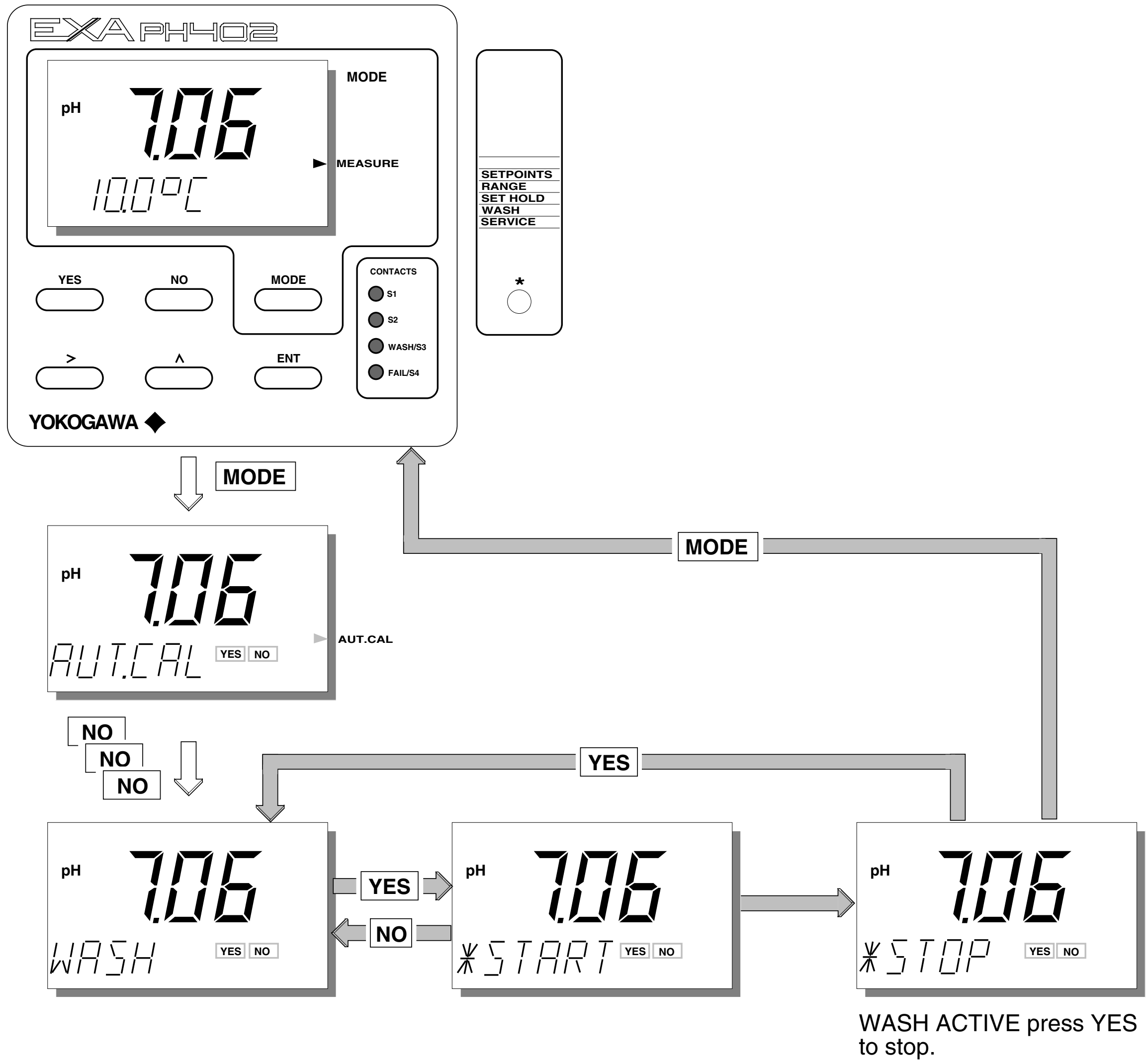


5-1-3. Manual activation of HOLD



Note: The HOLD feature must first be activated in the commissioning mode section 5-2-3.

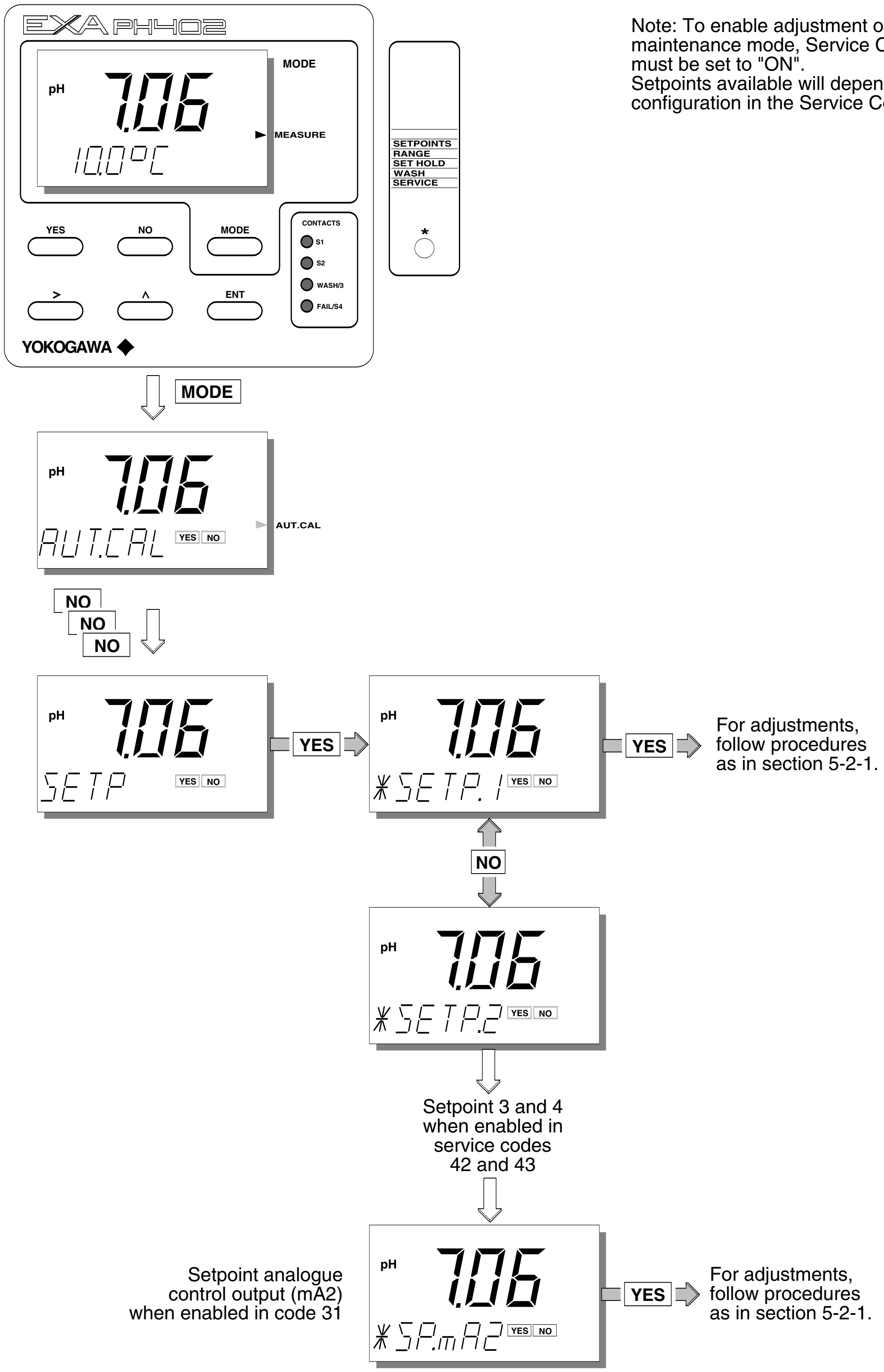
5-1-4. Manual wash start/stop



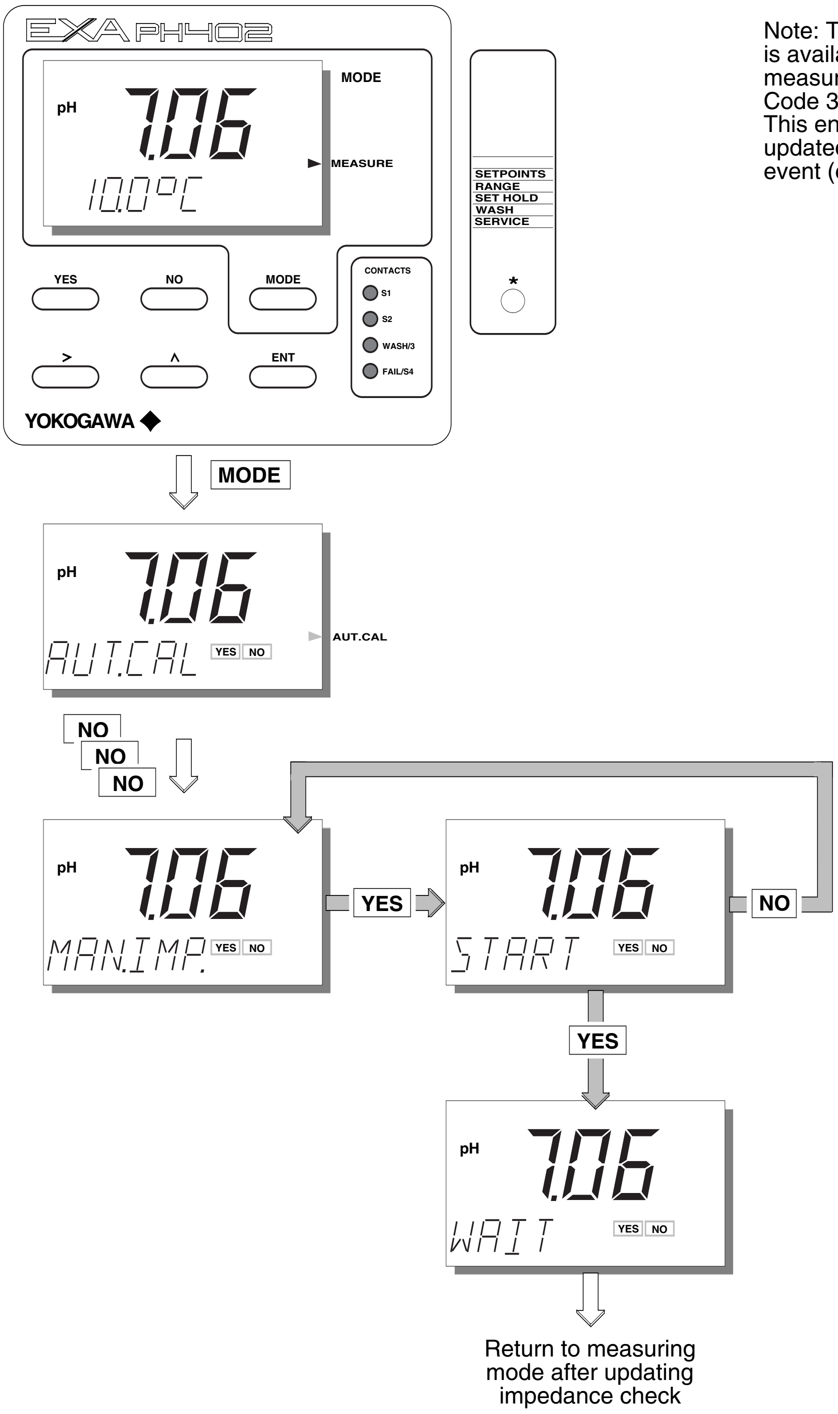
Note: Wash must first be switched on in commissioning mode section 5-2-4, and set for adjustment in the maintenance mode, by service code 51.

5-1-5. Setpoint adjustment

Note: To enable adjustment of setpoints in maintenance mode, Service Code 51 must be set to "ON".
Setpoints available will depend on their configuration in the Service Code.



5-1-6. Manual impedance check



Note: The manual impedance start is available when the sensor impedance measurement is enabled in Service Code 3 and 4.
This enables the impedance data to be updated immediately after a maintenance event (e.g. replacing an electrode).

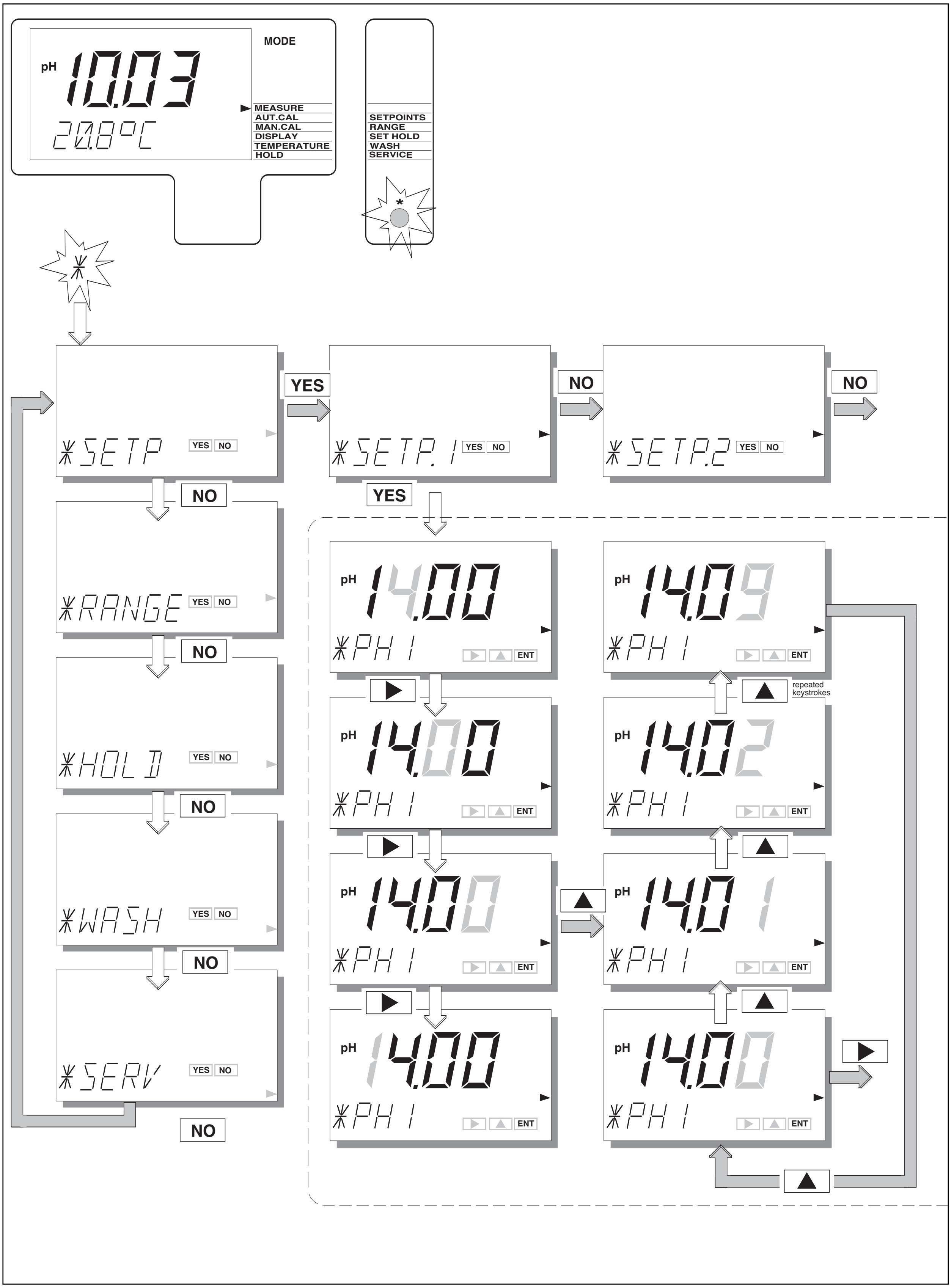
5-2. Commissioning mode

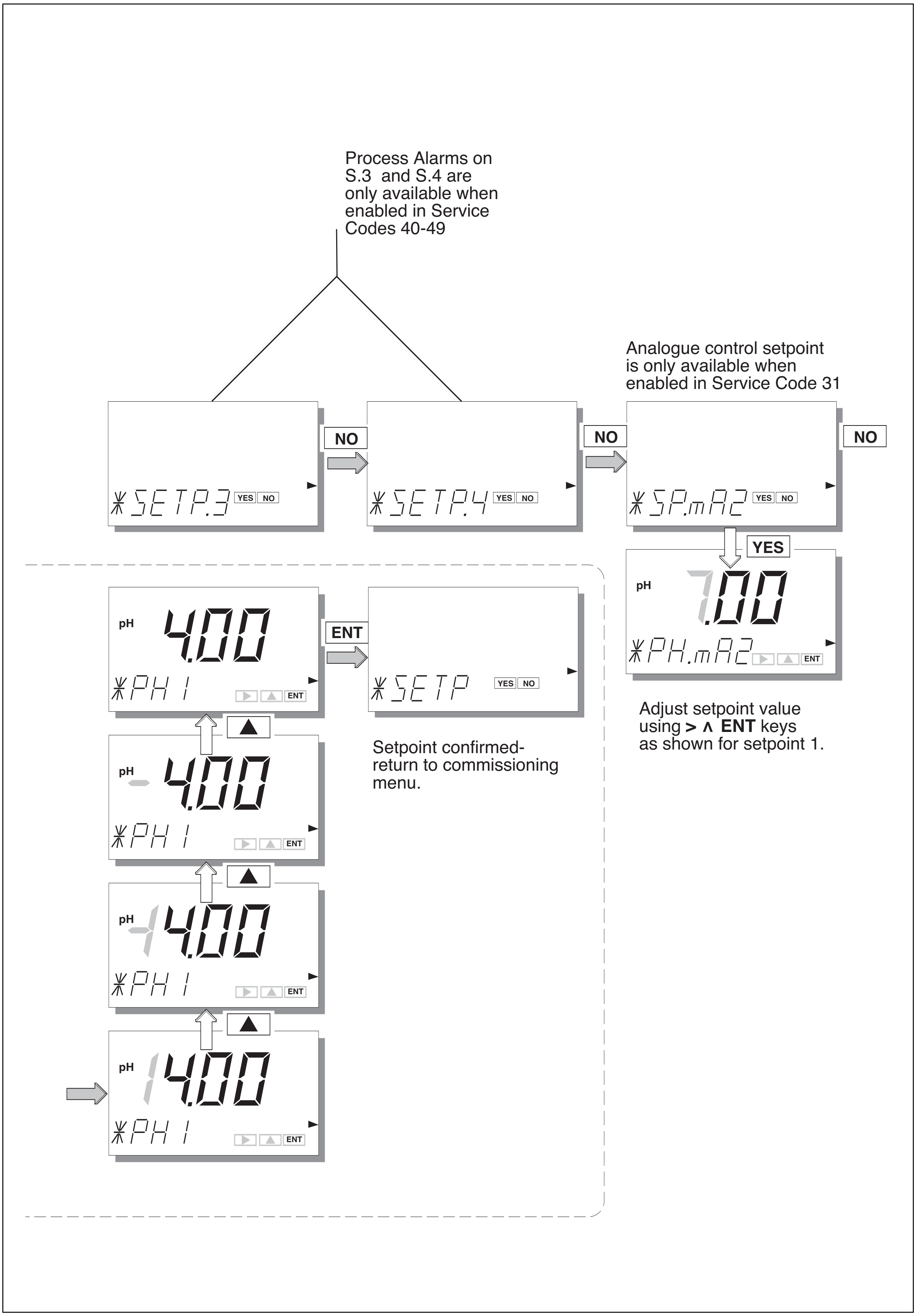
In order to obtain peak performance from the EXA, you must set it up for each custom application.

Setpoints	Alarms are set by default	S1 - high process alarm S2 - low process alarm S3 - WASH S4 - FAIL
	The setpoints are at arbitrary default value. Therefore, you must set these to meaningful values, or set them to off. (See service codes 40 to 49 and user interface codes 50 to 59).	
Output ranges	mA output 1 is set as default to 0 - 14 pH mA output 2 is set as default to 0 - 100 °C For enhanced resolution in more stable measuring processes, it may be desirable to select 5 - 10 pH range, for example, and maybe 0 - 25 °C temperature range. Service codes 30 to 39 can be used to choose other output parameters on mA output 2. Choose from ORP, temperature, rH or PI control.	
Hold	The EXA converter has the ability to “hold” the output during maintenance periods. This parameter should be set up to hold the last measured value, or a fixed value to suit the process.	
Wash cleaner	The EXA can be set up to control a wash cleaner. When using this function, the timings must be configured for interval, wash and recovery periods.	
Service	This selection provides access to the service menu.	

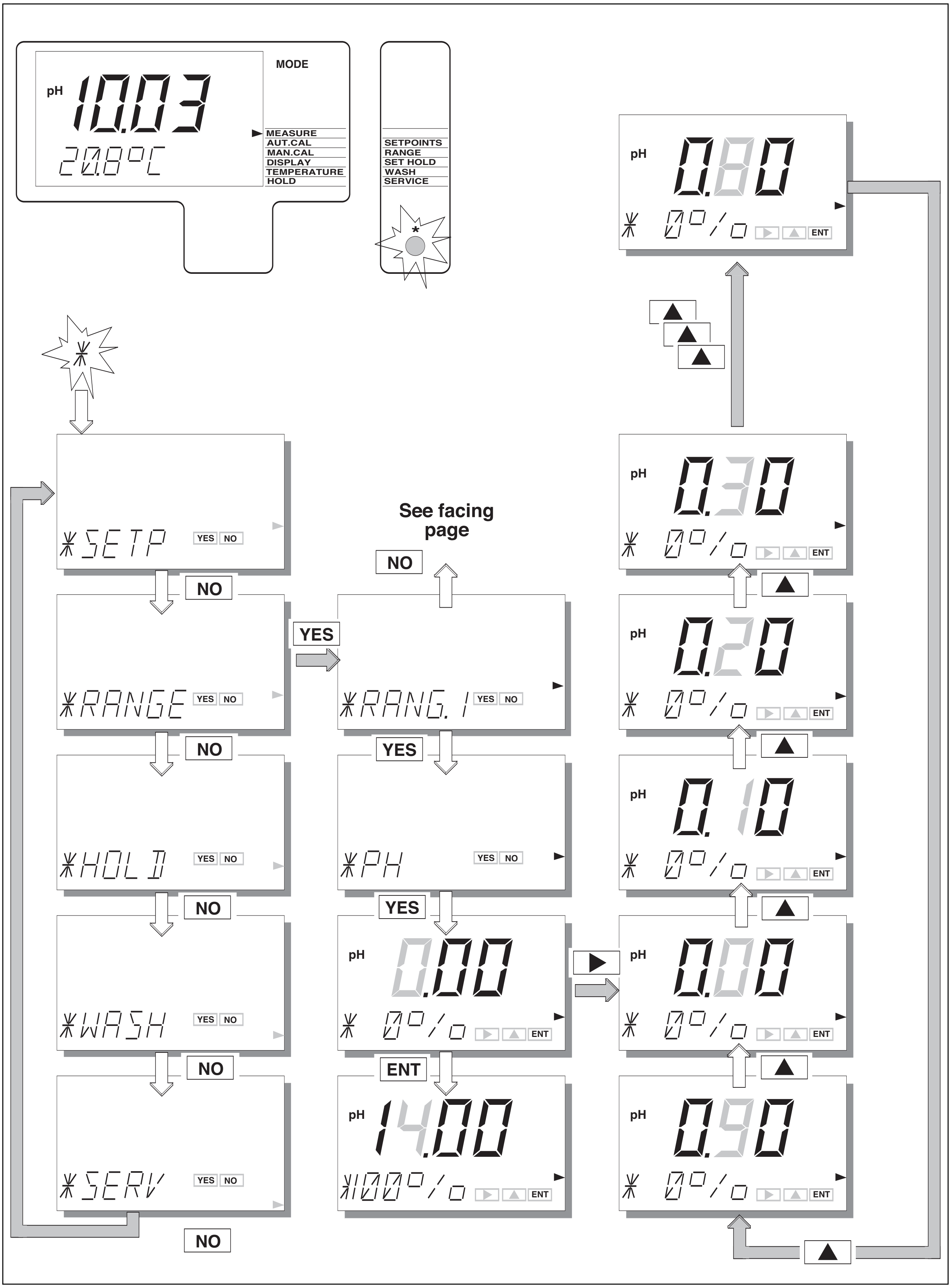
What follows are pictorial descriptions of typical frontplate pushbutton sequences for each parameter setting function. By following the simple YES/NO prompts and arrow keys, users can navigate through the process of setting range, setpoints, hold, wash and service functions.

5-2-1. Setpoints




Process Alarms on S.3 and S.4 are only available when enabled in Service Codes 40-49
Analogue control setpoint is only available when enabled in Service Code 31
NO
NO
NO
YES
ENT
pH
YES NO
ENT
Adjust setpoint value using > ∧ ENT keys as shown for setpoint 1.
Setpoint confirmed- return to commissioning menu.

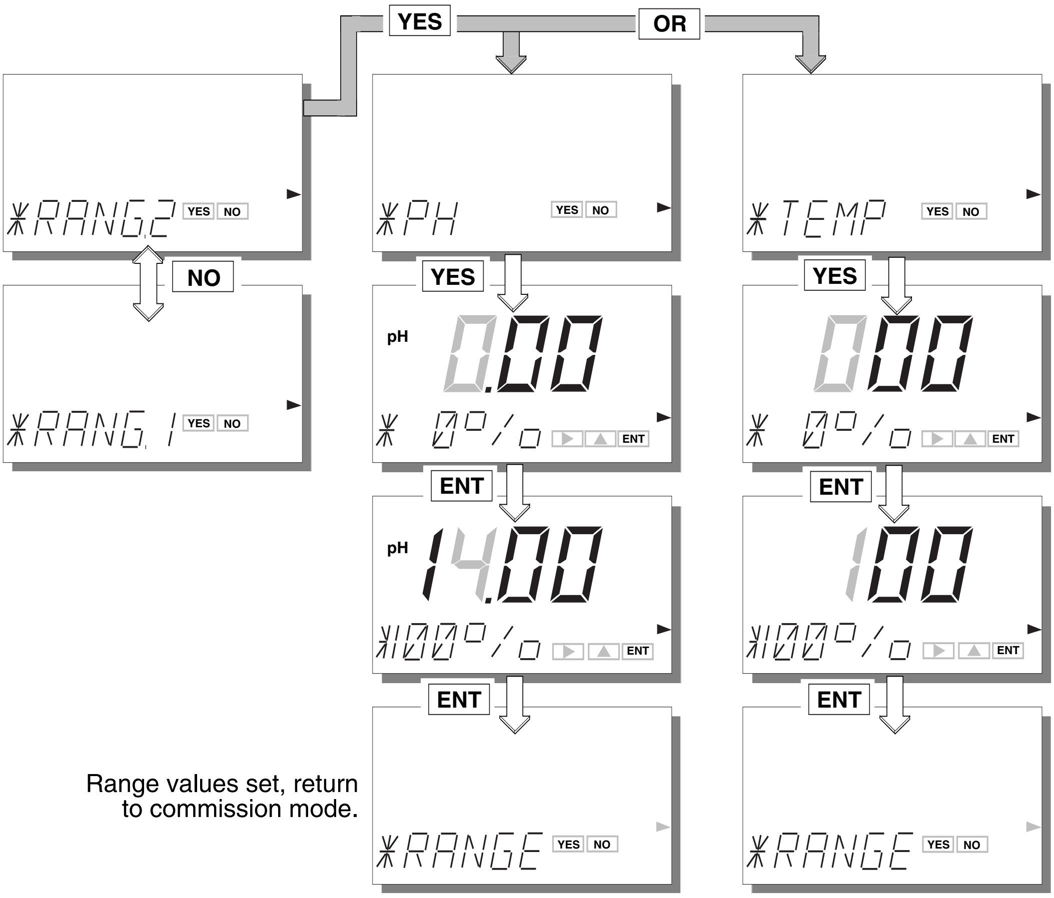
5-2-2. Range


MODE
MEASURE
AUT.CAL
MAN.CAL
DISPLAY
TEMPERATURE
HOLD
SETPOINTS
RANGE
SET HOLD
WASH
SERVICE
See facing page
NO
YES
ENT

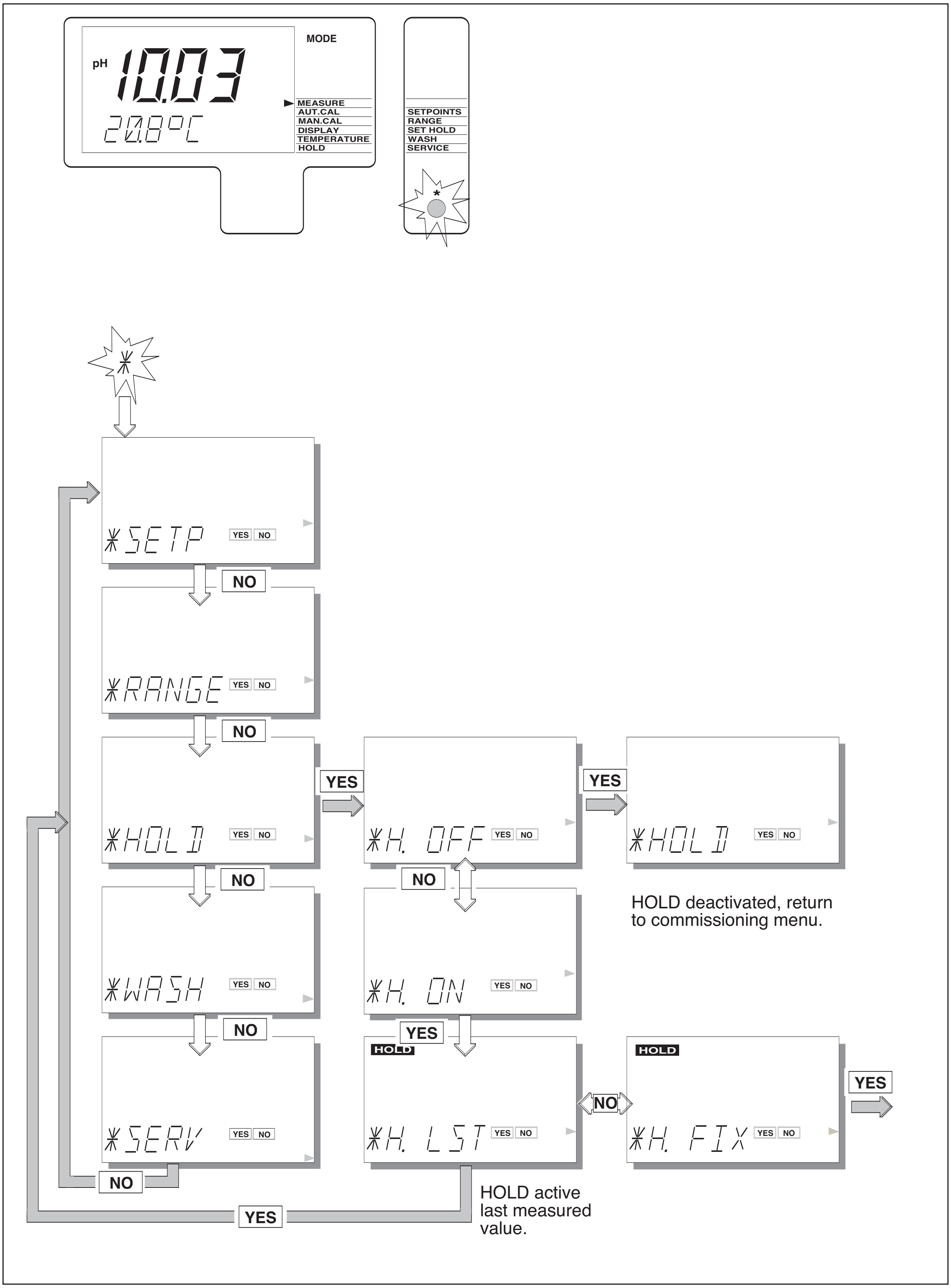
Choose Range to adjust, then set begin scale (0%) and end scale (100%) of the mA output signal, using the >,ʌ,and **ENT** keys. Selection of mA output (0-20 / 4-20 mA) is in Service Code 30.

Note: Range 2 does not appear when PI control set on mA2

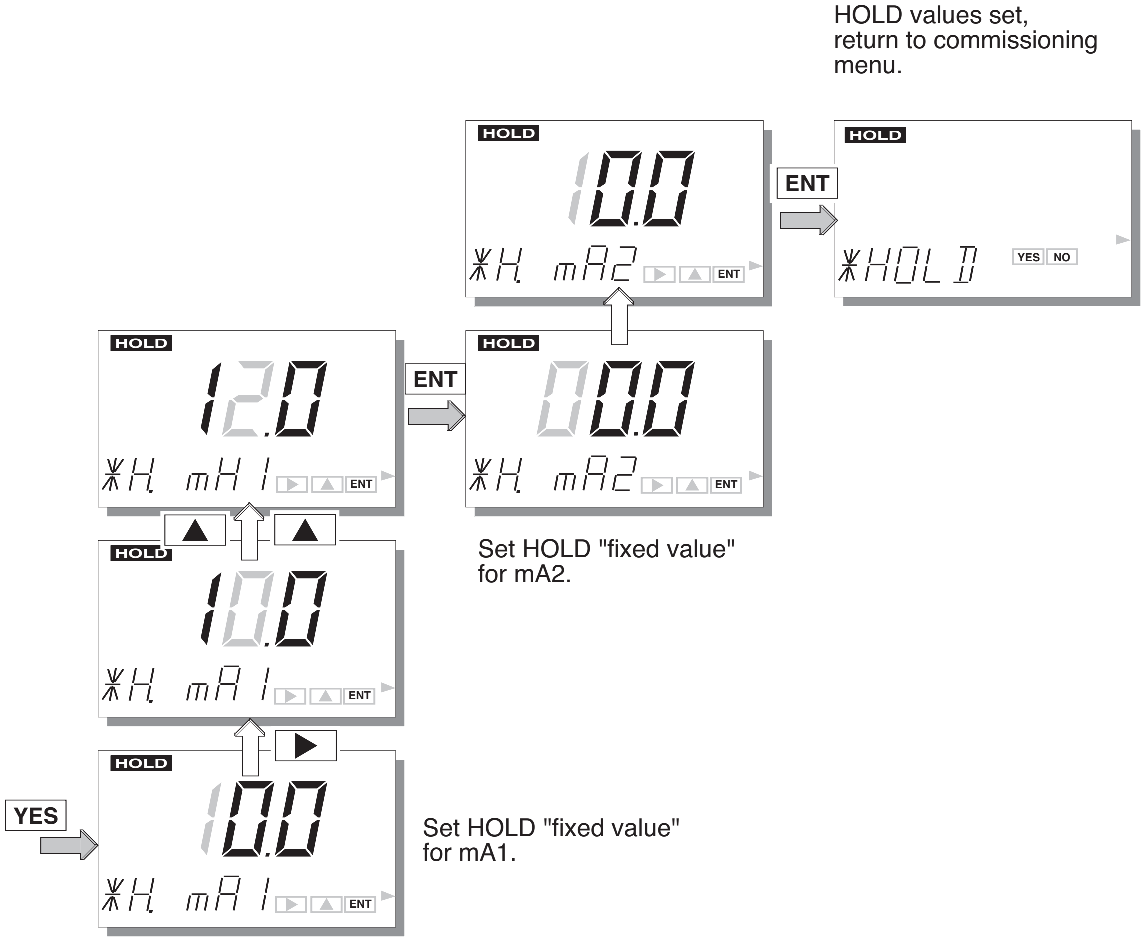
Range Selection Options are determined by Service Code 31



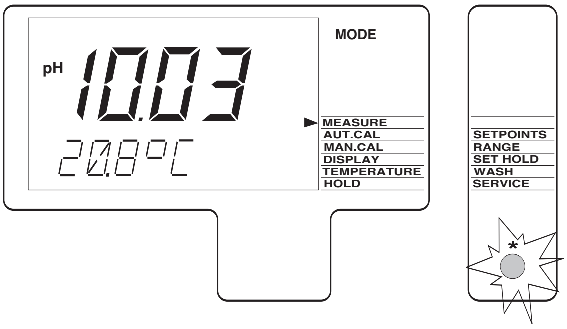
5-2-3. Hold



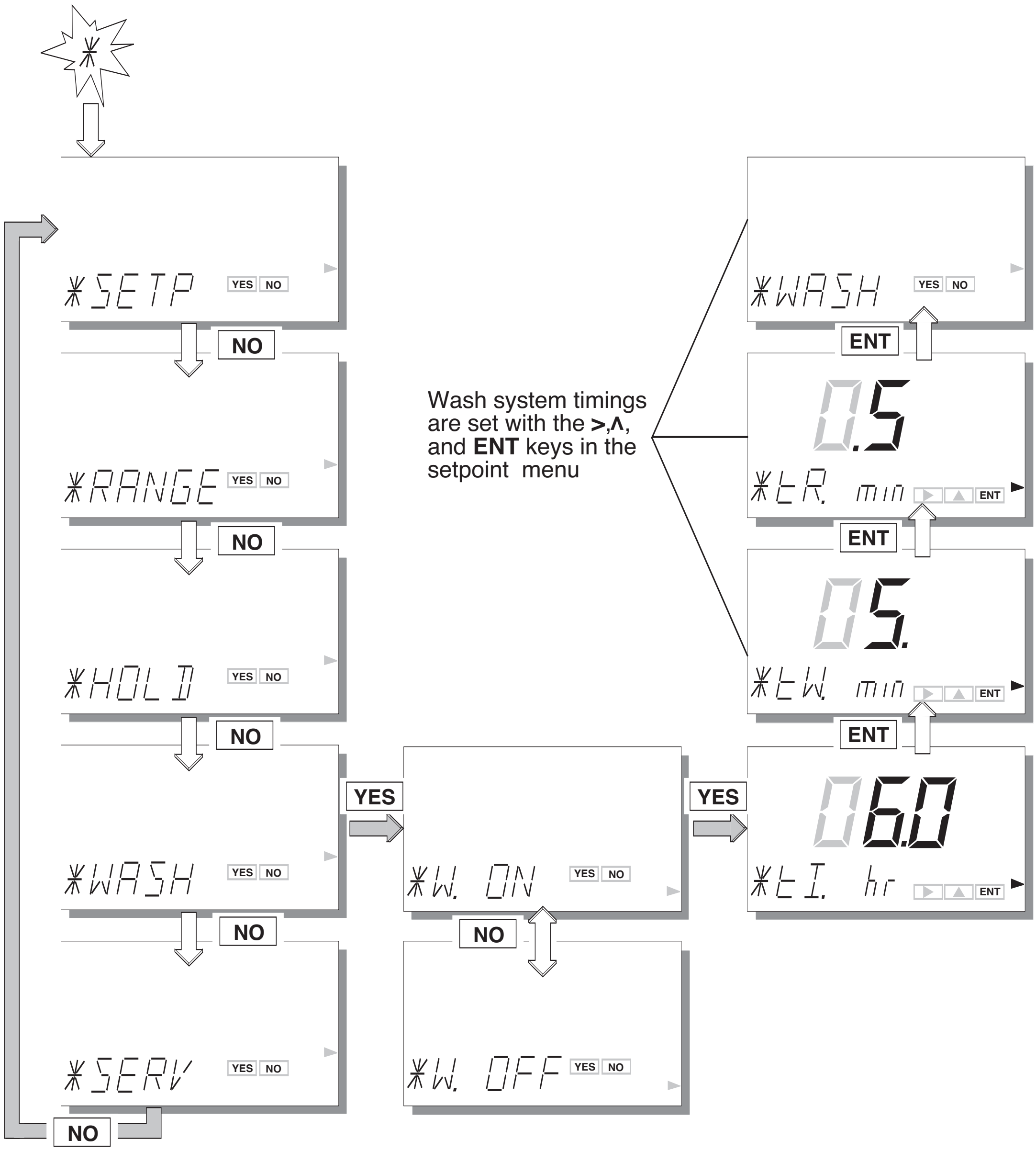
pH 10.03
20.8°C
MODE
MEASURE
AUT.CAL
MAN.CAL
DISPLAY
TEMPERATURE
HOLD
SETPOINTS
RANGE
SET HOLD
WASH
SERVICE
*SETP
*RANGE
*HOLD
*WASH
*SERV
*H. OFF
*H. ON
*H. LST
*H. FIX
HOLD
YES
NO
HOLD deactivated, return to commissioning menu.
HOLD active last measured value.


HOLD values set,
return to commissioning
menu.
HOLD
10.0
*H. mA2
ENT
HOLD
*HOLD
YES
NO
HOLD
12.0
*H. mA1
ENT
HOLD
00.0
*H. mA2
Set HOLD "fixed value"
for mA2.
HOLD
10.0
*H. mA1
YES
HOLD
10.0
*H. mA1
Set HOLD "fixed value"
for mA1.

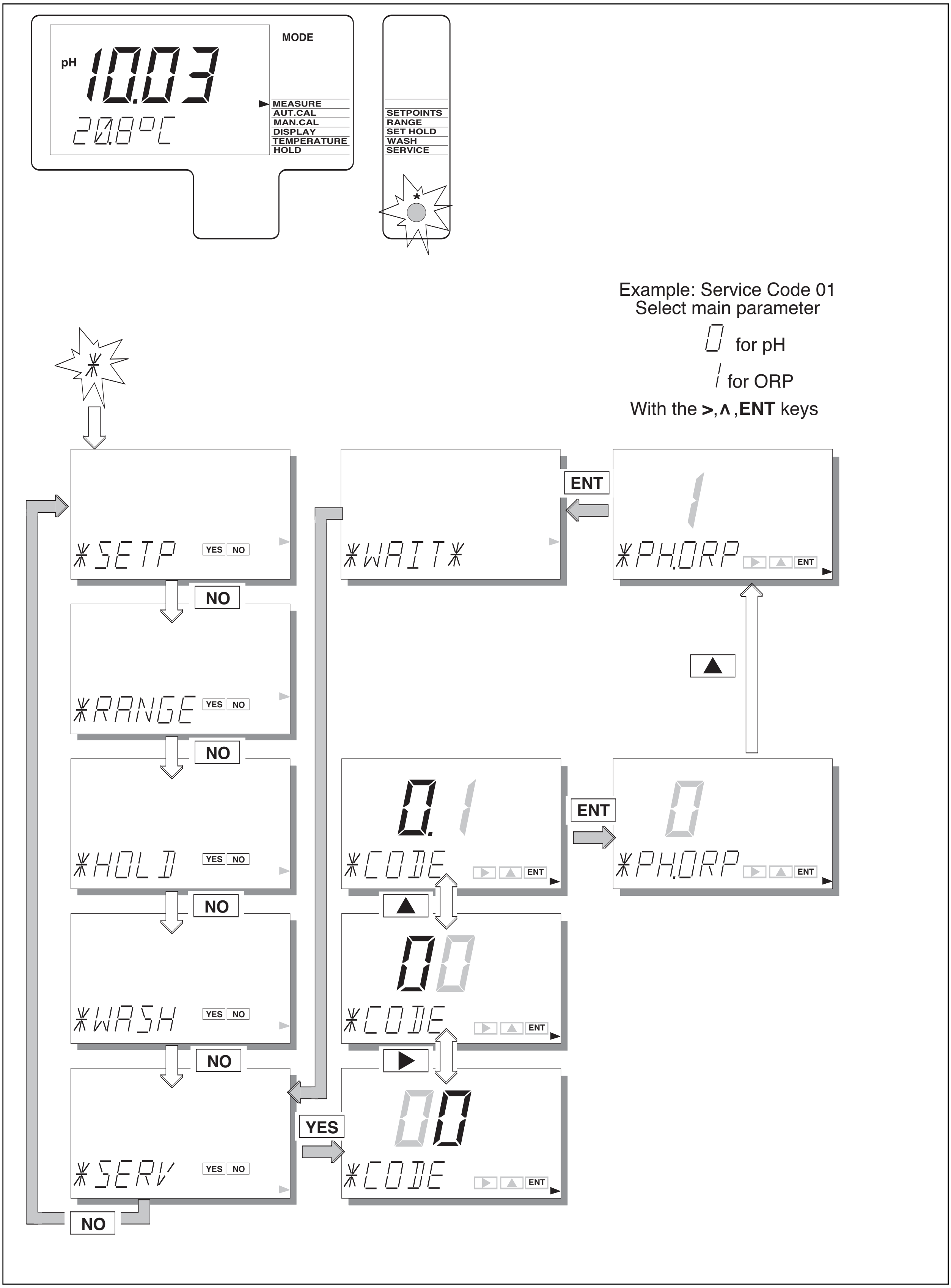
5-2-4. Wash



(NOTE: The menu item "WASH" will not appear unless selected in Service Code 42)



5-2-5. Service


MODE
pH 10.03
20.8°C
MEASURE
AUT.CAL
MAN.CAL
DISPLAY
TEMPERATURE
HOLD
SETPOINTS
RANGE
SET HOLD
WASH
SERVICE
Example: Service Code 01
Select main parameter
0 for pH
1 for ORP
With the >,∧,ENT keys
*SETP YES NO
NO
*RANGE YES NO
NO
*HOLD YES NO
NO
*WASH YES NO
NO
*SERV YES NO
NO
YES
*CODE 00
*CODE 00
*CODE 01
ENT
*PH.ORP 0
*PH.ORP 1
ENT
WAIT

5-3. Notes for guidance in the use of service coded settings

5-3-1. Parameter specific functions

Code 1	pH/ORP	Choose the main measuring parameter. The option of the ORP input is used with an inert metal electrode as measuring sensor which gives a reading directly in millivolts. This signal can then be interpreted to give information about the oxidation state of the process solution, and derived information like the absence of a compound (like Cyanide for example which is destroyed in oxidizing solutions).
Code 2	PRM.2	Enable the use of a second measuring parameter simultaneously with pH (the main parameter). With the correct sensor (e.g. FU20), ORP measurement is possible as parameter 2. With the same sensor, rH measurement is possible as parameter 2, this is calculated from pH and ORP and is a value which gives the oxidizing power of the solution while compensating for the effect of pH. This function is particularly useful for applications where both the pH and oxidation-reduction potential of the process need to be controlled. The availability of both measurements in a single system is much more convenient, (and more economical) than two separate systems. Note that in both cases a suitable sensor combination is needed to make this possible. The Yokogawa FU20 (4-in-1) sensor can be used for this purpose, or a combination of individual sensors. Contact your local Yokogawa sales office for advice regarding applications and sensor selection.
Code 3 & 4	Z1.CHK & Z2.CHK	The EXA PH402 has an impedance check capable of monitoring the impedance of all sorts of sensor systems. In order to "fine tune" this diagnostic tool it is necessary to set it up to match the sensors used. The default settings give a good setup for a conventional system comprising pH glass sensor and a reference electrode, either as individual electrodes or as a combination style sensor. The impedance limits will need to be adjusted to get the best from systems using heavy duty, or fast response electrodes. The impedance measuring system has a very wide span requirement. As it can measure in kΩ and also in GΩ (10^9) there are hardware switches to set high range (1MΩ to 2 GΩ) or low range (1kΩ to 1MΩ) measuring. As a default the system is set to measure high impedances on input 1 (the one normally used for the pH glass sensor input) and low impedances on input 2 (the one normally used for the reference input). Examples of where these settings need to be changed from the default, are Pfaudler enamel sensors which need two high impedance settings, and Platinum sensors with a standard reference, which need two low impedance settings. In applications that have a tendency to leave deposits on the electrodes, and to clog the reference sensor junction there is the possibility to use the impedance check on the reference sensor to initiate the wash cleaning process. This provides an excellent way of handling variable processes and intermittent batch operations. The temperature compensation of the impedance measurement is for conventional pH glass sensors. When other sensors are used, switch this feature off.
Code 5	CAL.CK	The calibration checking feature, when enabled, gives security against entering wrong calibration data. For example when aged sensors are due for replacement, the EXA flags an error message and prevents a calibration being completed where the subsequent measurement can only exhibit errors and drift. Limits are set for the maximum permissible Asymmetry potential, and Slope.

Code	Display	Function	Function detail	X	Y	Z	Default values	
Parameter specific functions								
01	*PH.ORP	Select main parameter	pH	0			0	pH
			ORP	1				
02	*PRM.2	Enable 2nd parameter	Off	0			0	Off
			ORP	1				
			rH	2				
03	*Z1.CHK	Impedance check 1	Low	0			1.1.1	
			High	1				High
			Temp comp off		0			
			Temp comp on		1			On
			Imp check off			0		
			Imp check on			1		On
	*Z.L.xΩ	Low impedance limit	Press NO to step through choice of units,					1 MΩ
		x = None, K, M or G	press YES to select units, then use the					
			>, ^ ENT keys to set the value					
	*Z.H.xΩ	High impedance limit	Press NO to step through choice of units,					1 GΩ
			press YES to select units, then use the					
			>, ^ ENT keys to set the value					
04	*Z2.CHK		Low	0			0.0.1	Low
			High	1				
			Temp comp off		0			Off
			Temp comp on		1			
			Imp check off			0		
			Imp check on			1		On
			Imp check on with wash start high imp.			2		
	*Z.L.xΩ	Low impedance limit	Press NO to step through choice of units,					100 Ω
		x = None, K, M or G	press YES to select units, then use the					
			>, ^ ENT keys to set the value					
	*Z.H.xΩ	High impedance limit	Press NO to step through choice of units,					200 kΩ
			press YES to select units, then use the					
			>, ^ ENT keys to set the value					
05	*CAL.CK	Calibration check	Asymmetry check off	0			1.1	
			Asymmetry check on	1				On
			Slope check off		0			
			Slope check on		1			On
06-09			Not used					

5-3-2. Temperature compensation and measuring functions.

Code 10	T.SENS	Selection of the temperature compensation sensor. The default selection is the Pt1000 Ohm sensor, which gives excellent precision with the two wire connections used. The other options give the flexibility to use a very wide range of other pH sensors.
Code 11	T.UNIT	Celsius or Fahrenheit temperature scales can be selected to suit user preference.
Code 12	T.ADJ	With the process temperature sensor at a stable known temperature, the temperature reading is adjusted in the main display to correspond. The calibration is a zero adjustment to allow for the cable resistance, which will obviously vary with length. The normal method is to immerse the sensor in a vessel with water in it, measure the temperature with an accurate thermometer, and adjust the reading for agreement.
Code 13	T.COMP	Process compensation automatically allows for changes in the pH of the process with temperature. The characteristic of each process will be different, and the user should determine if this feature is to be activated, and what compensation figure to choose. The compensation is given in pH per 10 °C. Example:- For pure water with an alkali dose, (e.g. boiler feed water) a coefficient of approx. 0.35pH can be expected. However, applications vary and a simple test will determine what if any coefficient is suitable for the process.

Code	Display	Function	Function detail	X	Y	Z	Default values	
Temperature measuring and compensation functions								
10	*T.SENS	Temperature sensor	Pt1000	0			0	Pt1000
			Pt100	1				
			3kBalco	2				
			5k1	3				
			8k55	4				
			10kPTC	7				
11	*T.UNIT	Display in °C or °F	°C	0			0	°C
			°F	1				
12	*T.ADJ	Calibrate temperature	Adjust to allow for cable resistance					None
13	*T.COMP	Set temp comp	Compensation for process changes off	0			0	Off
			Compensation for process changes on	1				
	*T.COEF	Adjust process TC	Set for TC in pH per 10 °C				- 0.0	pH per 10 °C
14-19			Not used					

5-3-3. Calibration Functions

Code 20	Δt.SEC & ΔpH	These functions are used to determine the stability level demanded by the EXA as acceptance criteria for the automatic calibration. The default settings give a good calibration for general purpose electrode systems with a fast response. Where heavy duty electrodes are used, or when low temperatures are concerned, these values should be adjusted. When adjusting these settings, the longer the time interval and the smaller the pH change, the more stable will be the reading. However, it is important to bear in mind that the time taken to reach stability is an exponential function, and too ambitious a setting will cause the instrument to wait for a very long time before accepting a calibration.
Code 21	AS.LOW & AS.HI	Limit values for the drift of an electrode system before an error is signalled when a calibration is done. These default values should be adjusted to suit the application, this will be especially important will enamel or Antimony probes.
Code 22	SL.LOW & SL.HI	Limit values for acceptable slope (sensitivity) calibrations.
Code 23	ITP, SLOPE & ASPOT	Values can be entered directly in this section. These data can be provided by the manufacturer of the probe, or by the users laboratory etc. They are determined independently of the measuring loop. NOTE: it is not necessary to enter this data in most cases as the EXA automatically does this while performing a calibration. The feature is used in the case of special electrode systems and where calibration in the process environment is not possible.
Code 24, 25, & 26	Buffer tables	The following buffer calibration tables are programmed into the EXA. They are the primary buffer standards according to NIST (formerly NBS) and various other national standards. We strongly recommend the use of these buffer solutions as they give the best buffer capacity, reliability and accuracy when calibrating.

Table 5-1.

	pH 4	pH 7	pH 9		pH 4	pH 7	pH 9
0 °C	4.00	6.98	9.46	**45 °C**	4.05	6.83	9.04
5 °C	4.00	6.95	9.40	**50 °C**	4.06	6.83	9.01
10 °C	4.00	6.92	9.33	**55 °C**	4.08	6.83	8.99
15 °C	4.00	6.90	9.28	**60 °C**	4.09	6.84	8.96
20 °C	4.00	6.88	9.23	**65 °C**	4.11	6.84	8.94
25 °C	4.01	6.87	9.18	**70 °C**	4.13	6.85	8.92
30 °C	4.02	6.85	9.14	**75 °C**	4.15	6.85	8.90
35 °C	4.02	6.84	9.10	**80 °C**	4.16	6.86	8.89
40 °C	4.04	6.84	9.07				

These tables may be adjusted in the case that the user wishes to use other calibration solutions. The "name" of the buffer can be changed at the *BUF.ID prompt. The other values can then be adjusted in sequence.

Code 27	Zero Point	As an alternative to Asymmetry Potential, the Zero point can be used to define and calibrate the EXA pH unit. Note that this method conforms to the DIN standard for instruments No. IEC 746-2.

Code	Display	Function	Function detail	X	Y	Z	Default values	
Calibration functions								
20	*Δt.SEC *ΔPH	Stability check time Stability check pH						5 sec. 0.02 pH
21	*AS.LOW *AS.HI	As Pot low limit As Pot high limit						-120 mV 120 mV
22	*SL.LOW *SL.HI	Slope low limit Slope high limit						70 % 110 %
23 (pH)	*ITP *SLOPE *ASP.1D *ASP *ASPmV	Set ITP Set slope Set As Pot Set As Pot Set As Pot ORP	Preset calibration data from manufacturer or from laboratory determinations. For the main parameter Press YES to confirm 0.1 mV resolution, then set value with >, ^, ENT keys. Press NO to change to *ASP. For the main parameter Press YES to confirm 1 mV resolution, then set value with >, ^, ENT keys. For parameter 2 (when activated in service code 02)					7.00 pH 100 % 0.0 mV
23 (ORP)	*ASP.1D *ASP	Set As Pot (ORP) Set As Pot	For the main parameter Press YES to confirm 0.1 mV resolution, then set value with >, ^, ENT keys. Press NO to change to *ASP. For the main parameter Press YES to confirm 1 mV resolution, then set value with >, ^, ENT keys.					
24	*BUF.ID	Buffer table 4	Buffer tables to NIST (formerly NBS)					
25	*BUF.ID	Buffer table 7	(see section 10 for table details)					
26	*BUF.ID	Buffer table 9	User adjustable for special requirements					
27	*ZERO.P	Enable zero point in pH units	Disable zero point (enable As Pot) Enable zero point (disable As Pot)	0 1			0	Disabled
28-29			Not used					

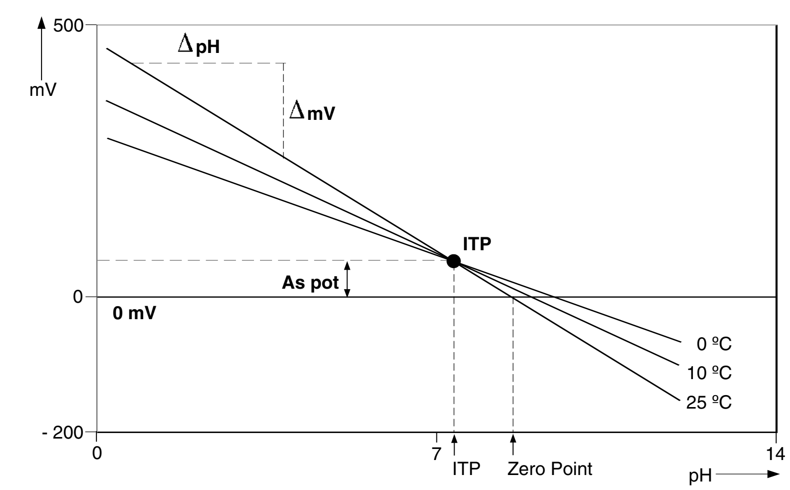


Fig. 5-1.

5-3-4. mA Output functions

Code 30	*mA	Select required output signal. 0-20 or 4-20mA to suit associated equipment (Recorders, controllers etc.).
Code 31	OUTP.F	Select the parameters to transmit on the two mA output signals mA1 & mA2.

Note: The available choices are affected by the selection of primary parameter (pH/ORP) in service code 01, and the selection of secondary parameter (off/ORP/rH) in service code 02.

With pH selected as parameter 1, the default configuration is with mA1 as linear pH output, and mA2 as temperature.
The choices for mA1 (on terminals 61 & 62) are: linear pH, pH table output (21pt curve), linear parameter 2 (ORP/rH).
The choices for mA2 (a terminal 64 & 65) are: linear pH, pH table, linear temperature, pH control (PI), parameter 2 control (PI).

Note: To transmit pH (parameter 1) and ORP/rH (parameter 2) simultaneously, set mA1 for ORP/rH (parameter 2) and mA2 for pH (parameter 1). Service code 31 set to 2.0.

	P.I. Control	When PI control is selected for mA2 (choice 3 or 4) a further configuration step is needed.
	*D/R	This sets the direction of the control action. Direct is a rising output with rising signal. Reverse is a falling output with rising signal.

With ORP selected as parameter 1, the default configuration is with mA1 as linear ORP output and mA2 as temperature. The choices for mA1 (on terminals 61 & 62) are: linear ORP, ORP table output (21pt curve).
The choices for mA2 (a terminal 64 & 65) are: linear ORP, ORP table, linear temperature, ORP control (PI).

	P.I. Control	When PI control is selected for mA2 (choice 3) a further configuration step is needed.
	*D/R	This sets the direction of the control action. Direct is a rising output with rising signal. Reverse is a falling output with rising signal.
Code 32	BURN	Diagnostic error messages can signal a problem by sending the output signals upscale or downscale (22mA or 0/3.5mA). This is called upscale or downscale burnout, from the analogy with thermocouple failure signalling of a burned-out or open circuit sensor. In the case of the EXA the diagnostics are extensive and cover the whole range of possible sensor faults.
Code 33	RG.mA2	This function sets the proportional range for the mA output control signal
Code 34	tI.mA2	This function sets the integral time for the mA output control signal
Code 35 & 36	TABLE	The table function allows the configuration of an output curve by 21 steps (intervals of 5%)

Table 5-2.

	0-20 mA	4-20 mA		0-20 mA	4-20 mA
0%	0 mA	4.0 mA	**50%**	10 mA	12.0 mA
5%	1 mA	4.8 mA	**55%**	11 mA	12.8 mA
10%	2 mA	5.6 mA	**60%**	12 mA	13.6 mA
15%	3 mA	6.4 mA	**65%**	13 mA	14.4 mA
20%	4 mA	7.2 mA	**70%**	14 mA	15.2 mA
25%	5 mA	8.0 mA	**75%**	15 mA	16.0 mA
30%	6 mA	8.8 mA	**80%**	16 mA	16.8 mA
35%	7 mA	9.6 mA	**85%**	17 mA	17.6 mA
40%	8 mA	10.4 mA	**90%**	18 mA	18.4 mA
45%	9 mA	11.2 mA	**95%**	19 mA	19.2 mA
			100%	20 mA	20.0 mA

Code	Display	Function	Function detail	X	Y	Z	Default Values	
mA Outputs								
30	*mA	output signal	0-20 mA on mA1	0			1.1	
			4-20 mA on mA1	1				mA1 4-20
			0-20 mA on mA2		0			
			4-20 mA on mA2		1			mA2 4-20
31	The choices below appear when pH was selected in service code 01							
pH	*OUTP.F	Output Parameter	pH on mA1	0			0.2	pH on mA1
			pH (table) on mA1	1				
			Parameter 2 (ORP or rH) on mA1	2				
			pH on mA2		0			
			pH (table) on mA2		1			
			Temperature on mA2		2			Temp. on mA2
			pH PI control on mA2		3			
			Parameter PI control on mA2		4			
	*D/R	Direct or reverse acting PI control	For rising signal, set for decreasing mA output	0			0	Reverse
			For rising signal, set for increasing mA output	1				
31	The choices below appear when ORP was selected in service code 01							
ORP	*OUTPUT.F	Output parameter	ORP on mA1	0			0.2	ORP on mA1
			ORP (table) in mA1	1				
			ORP on mA2		0			
			ORP (table) on mA2		1			
			Temperature on mA2		2			Temp on mA2
			ORP PI control on mA2		3			
	*D/R	Direct or reverse acting PI control	For rising signal, set for decreasing mA output	0			0	Reverse
			For rising signal, set for increasing mA output	1				
32	*BURN	Burn function	mA 1 No burnout	0			0.0	No Burn.
			mA 1 Burnout downscale	1				
			mA 1 Burnout upscale	2				
			mA 2 No burnout		0			No Burn.
			mA 2 Burnout downscale		1			
			mA 2 Burnout upscale		2			
33	*RG.mA2	PI range	Proportional range for mA control signal					
	*pH.mA2	Display depends on	(use >, ^, ENT keys to adjust value)					1.0 pH
	*mV.mA2	parameter selected						2.0 rH
	*rH.mA2	in code 31						50 mV
34	*tI.mA2	Integral time (for PI control)						100 sec.
35	*TABL1	Output table for mA1						
	*0%		Linearisation table for mA1 in 5% steps.					
	*5%		The measured value is set in the main					
	*10%		display using the >, ^, ENT keys, for					
	...		each of the 5% interval steps.					
	...		Where a value is not known, that value may					
	*90%		be skipped, and a linear interpolation will					
	*100%		take place.					
36	*TABL2	Output table for mA2						
	*0%		Linearisation table for mA2 in 5% steps.					
	*5%		The measured value is set in the main					
	*10%		display using the >, ^, ENT keys, for					
	...		each of the 5% interval steps.					
	...		Where a value is not known, that value may					
	*90%		be skipped, and a linear interpolation will					
	*100%		take place.					
37-39			Not used					

5-3-5. Contact outputs

Code 40 & 41	*S1 & *S2	Process relays can be set for a variety of alarm and control function. Digit "X" sets the type of trigger: Off means that the relay is not active Low setpoint means that the relay is triggered by a decreasing measurement. High setpoint means that the relay is triggered by an increasing measurement "HOLD" active means that there is maintenance activity in progress so the measurement is not live. For *S3 There is the extra possibility to set up for a wash controller. For *S4 There is the extra possibility to set up for "FAIL" indication. Digit "Y" sets the control action: Process alarm is a simple On/Off trip controlled by the high/low setpoint. Proportional duty cycle control has a pulse width modulation for proportional dosing with solenoid valves. Proportional frequency control is used for controlling electrically positioned valves. Temperature alarm is an On/Off trip on the measured temperature. Digit "Z" sets the control parameter: Alarm on main process Control on main process (Main process means pH/ORP depending on the setting of service code #1) Alarm on rH Control on rH (Available only when pH set in service code #1 & parameter 2 is set to rH in service code #2.

Code	Display	Function	Function detail	X	Y	Z	Default values	
Contacts								
40	*S1	Relay 1 settings	Off	0			2.0.0	
			Low setpoint	1				
			High setpoint	2				High
		Note: Main process	"HOLD" active	3				
		means pH or ORP	Process alarm		0			Alarm
		whichever is set in	Proportional duty cycle control		1			
		code #1	Proportional frequency control		2			
			Temperature alarm		3			
			Alarm on main process			0		Main
			PI control on main process			1		
			Alarm on rH			2		
			PI control on rH			3		
41	*S2	Relay 2 settings	Off	0			1.0.0	
			Low setpoint	1				Low
			High setpoint	2				
		Note: "HOLD" active	"HOLD" active	3				
		relay contact is used	Process alarm		0			Alarm
		to indicate when the	Proportional duty cycle control		1			
		measuring mode is	Proportional frequency control		2			
		interrupted	Temperature alarm		3			
			Alarm on main process			0		Main
			PI control on main process			1		
			Alarm on rH			2		
			PI control on rH			3		
42	*S3	Relay 3 settings	Off	0			4.0.0	
			Low setpoint	1				
			High setpoint	2				
			"HOLD" active	3				
		Note: "WASH" relay	Wash control	4				WASH
		contact is used to	Process alarm		0			Alarm
		control the flow of	Proportional duty cycle control		1			
		cleaner to a sensor	Proportional frequency control		2			
		wash nozzle	Temperature alarm		3			
			Alarm on main process			0		Main
			PI control on main process			1		
			Alarm on rH			2		
			PI control on rH			3		
43	*S4	Relay 4 settings	Off	0			4.0.0	
			Low setpoint	1				
			High setpoint	2				
			"HOLD" active	3				
		Note: "FAIL" relay	Fail alarm	4				FAIL
		contact is used to	Process alarm		0			Alarm
		indicate when the	Proportional duty cycle control		1			
		diagnostics detect a	Proportional frequency control		2			
		problem	Temperature alarm		3			
			Alarm on main process			0		Main
			PI control on main process			1		
			Alarm on rH			2		
			PI control on rH			3		

Code 44	*D.TIME	The delay time sets the minimum relay switching time. This function can be adjusted to give a good alarm function in a noisy process, preventing the relay from "chattering" or repeatedly switching when the signal is close to the setpoint.
	*PH.HYS *mV.HYS *rH.HYS *T.HYS	The hysteris is the value beyond the setpoint that the measured value must exceed before the control function will start working.
Code 45	*RANGE	Proportional range is the value above (or below) the setpoint that generates full output in proportional control. This is in the units of the main parameter (pH or mV).
	*rH.RNG	This is the proportional range in rH and is only enabled when the converter is set up for rH measurement.
	*PER.	The time period of the overall pulse control cycle (one ON and one OFF period). See fig. 5-3.
	*FREQ.	The maximum frequency for the pulse frequency control. See fig 5-4.
Code 46	*tI.CNT	The integral time for the PI control settings.
Code 47	*EXPIR	When a system is set up to control on the relay outputs, the expiry time can be enabled to warn of an ineffective control. In other words, when the setpoint is exceeded for more than 15 minutes an error message is generated. This can mean, for example, that the reagent tank is empty.

Code	Display	Function	Function detail	X	Y	Z	Default values	
Contacts (continued)								
44	*D.TIME	Delay time	Minimum relay switching time					0.2 sec.
	*PH.HYS	Hysteresis pH	Minimum pH/ORP change for relay reset					0.1 pH
	*mV.HYS	Hysteresis ORP	after switching					10 mV
	*rH.HYS	Hysteresis rH	Minimum rH change for relay reset after switching					0.2 rH
	*T.HYS	Hysteresis temp.	Minimum temperature change for relay reset after switching (fig. 5-2)					1 °C
45	*RANGE	Proportional range	When proportional control selected in code 40, 41, 42 or 43					1 pH (10 mV)
	*rH.RNG	Proportional range rH	When rH proportional control selected in code 40, 41, 42 or 43					2 rH
	*PER.	Duty cycle period	Pulse control On time + Off time (fig. 5-3)					10 sec.
	*FREQ.	Maximum frequency	100% value for frequency control (fig. 5-4)					70 p/m
46	*tI.CNT	Integral time	Integral time for relay controls when PI is set					100 sec.
47	*EXPIR	Expiry time	Warning of ineffective control action On	0			0	Off
			Warning of ineffective control action Off	1				
	*tE min	Set expiry time					15	min
48-49			Not used					

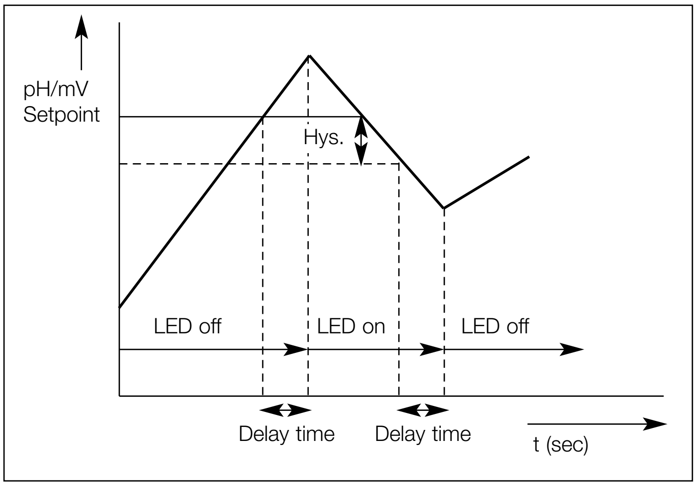


Fig. 5-2.

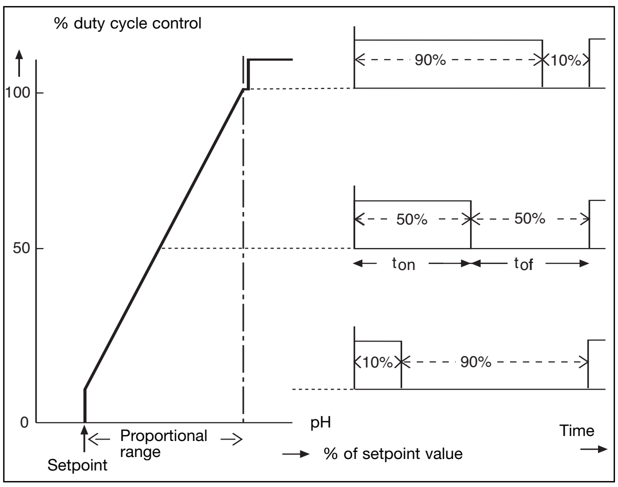


Fig. 5-3.

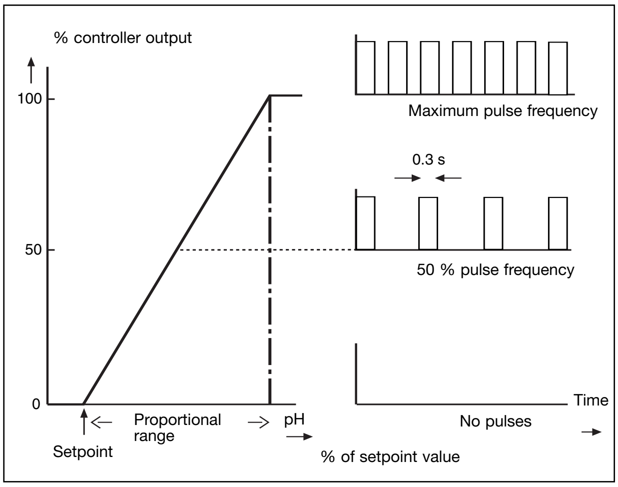


Fig. 5-4.

5-3-6. User interface

Code 50	*RET.	When Auto return is enabled, the converter reverts to the measuring mode from anywhere in the configuration menus, when no button is pressed during the set time interval of 10 minutes.
Code 51	*MODE	The adjustment of the contact setpoints, the manual operation of the wash system and a manual impedance check (on demand) can be setup for operation in the maintenance mode. (Through the closed front cover).
Code 52	*PASS	Passcodes can be set on any or all of the access levels, to restrict access to the instrument configuration.
Code 53	*Err.4.1	Error message configuration. Two different types of failure mode can be set. Hard fail gives a steady FAIL flag in the display, and a continuous contact closure. All the other contacts (controls) are inhibited (except HOLD contacts), and a Fail signal is transmitted on the outputs when enabled in code 32. Soft fail gives a flashing FAIL flag in the display, and the relay contacts are pulsed. The other contacts (controls) are still functional, and the controller continues to work normally. The call for maintenance is a good example of where a SOFT fail is useful. A warning that the regular maintenance is due, should not be used to shut down the whole measurement. *SOFT If soft set to 1, Soft fail only gives a flashing FAIL flag in the display and no pulsing contact
Code 54		Not used
Code 55	*CALL.M	Call for maintenance is a contact trigger to signal that the system has been in service for longer than the set time without calibration. The user can set up to 250 days as a routine service interval.
Code 56	*DISP	The display resolution can be set to either 0.01pH or 0.1pH. Not applicable to the ORP (mV) display.

Code	Display	Function	Function detail	X	Y	Z	Default values	
User interface								
50	*RET	Auto return	Auto return to measuring mode Off	0				
			Auto return to measuring mode On	1			1	On
51	*MODE	Mode setup	Setpoints in maintenance mode Off	0			0.0.0	Off
			Setpoints in maintenance mode On	1				
			Wash in maintenance mode Off		0			Off
			Wash in maintenance mode On		1			
			Manual impedance check Off			0		Off
			Manual impedance check On			1		
52	*PASS	Passcode	Maintenance passcode Off	0			0.0.0	Off
		Note # = 0 - 9, where	Maintenance passcode On	#				
		0 = no passcode	Commissioning passcode Off		0			Off
		1=111, 2=333, 3=777	Commissioning passcode On		#			
		4=888, 5=123, 6=957	Service passcode Off			0		Off
		7=331, 8=546, 9=847	Service passcode On			#		
53	*Err.4.1	Error setting	Impedance low (input 1) Soft fail	0				
			Impedance low (input 1) Hard fail	1			1	Hard
	*Err.5.1		Impedance high (input 1) Soft fail	0				
			Impedance high (input 1) Hard fail	1			1	Hard
	*Err.4.2		Impedance low (input 2) Soft fail	0				
			Impedance low (input 2) Hard fail	1			1	Hard
	*Err.5.2		Impedance high (input 2) Soft fail	0				
			Impedance high (input 2) Hard fail	1			1	Hard
	*Err.07		Temperature too high Soft fail	0				
			Temperature too high Hard fail	1			1	Hard
	*Err.08		Temperature too low Soft fail	0				
			Temperature too low Hard fail	1			1	Hard
	*Err.09		pH out of range Soft fail	0				
			pH out of range Hard fail	1			1	Hard
	*Err.11		Response (half-time fail) Soft fail	0			0	Soft
			Response (half-time fail) Hard fail	1				
	*Err.16		Call for maintenance Soft fail	0			0	Soft
			Call for maintenance Hard fail	1				
	*Err.22		Control time-out Soft fail	0			0	Soft
			Control time-out Hard fail	1				
	*SOFT		LCD + Fail contact	0			0	LCD/Fail
			LCD only	1				
54			Not used					
55	*CALL.M	Call for maintenance	Set time limit for calibration Off	0			0	Off
			Set time limit for calibration On	1				
56	*DISP	Display resolution	Set pH decimal display 0.1 pH	0				
			Set pH decimal display 0.01pH	1			1	0.01 pH
57-59			Not used					

5-3-7. Communication setup

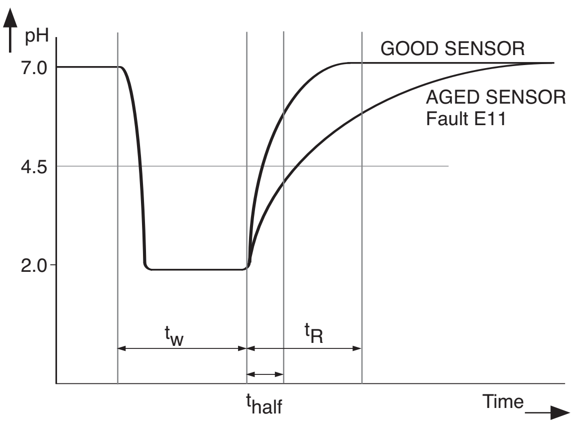
Code 60	*COMM. *SET. *ADDR.	The settings should be adjusted to suit the communicating device connected to the RS485 port. For the Yokogawa PC402 software package, the default settings match the software as shipped.
Code 61	*HOUR *MINUT *SECND *YEAR *MONTH *DAY	The clock/calendar for the logbook is set for current date and time as reference.
Code 62	*ERASE	Erase logbook function to clear the recorded data for a fresh start. This may be desirable when re-commissioning an instrument that has been out of service for a while.

5-3-8. General

Code 70	*LOAD	The load defaults code allows the instrument to be returned to the default set up with a single operation. This can be useful when wanting to change from one application to another.
Code 71	*tH.CHK	The wash cleaner can be used to test the response of the electrode system, see fig. 5-5. The online response check gives a very good indication of the condition of the electrode system. The first sign of deterioration of the sensors is usually the increase in response time.
Code 72	*W. REV	Wash reverse is used for very difficult applications where the process rapidly attacks the sensors, or coats them, or otherwise spoils the measurement. The wash is then operational most of the time, and is switched off to measure. This technique gives an output which is updated on a sample and hold basis. To obtain continuity of output is important therefore to set the hold to ON in the commissioning menu.
Code 79	*CUST.D	Load customer defaults. This code allows the instrument to be returned to the factory default set, except that buffer tables (code 24,25,26) are unchanged.

Code	Display	Function	Function detail		X	Y	Z	Default values	
Communication									
60	*COMM.	Communication	Set communication	Off	0			0.1	Off
			Set communication	On	1				
			Communication write enable			0			write
			Communication write protect			1			protect
	*SET.	Baud rate & parity	Baud rate	1200	0			3.1	
				2400	1				
				4800	2				
				9600	3				9600
			Parity	Off		0			
				Odd		1			Odd
				Even		2			
	*ADDR.	Network address	Set address 00 to 15					00	
61	*HOUR *MINUT *SECND *YEAR *MONTH *DAY	Clock setup	Adjust to current date and time using >, ^ and ENT keys						
62	*ERASE	Erase logbook	Press YES to clear logbook data						
63-69			Not used						

Code	Display	Function	Function detail		X	Y	Z	Default values	
General									
70	*LOAD	Load defaults	Reset configuration to default values						
71	*tH.CHK	Half-time check	Response check when washing	Off	0			0	Off
			Response check when washing	On	1				
72	*W. REV	Wash reverse	Long wash, short measuring time	Off	0				
			Long wash, short measuring time	On	1				
73-78			Not used						
79	*CUST.D	Load Customer Defaults	Reset configuration to default values except buffer tables						



Contact S3 is used to control the wash cycle.
- Adjustable parameters :
  Cleaning time or washing time (t_w)Recovery time after washing (t_r)
  Interval time for wash cycle
  An on-line dynamic response test of the electrode can be activated after cleaning. In the example shown, within the "half-time" the pH should recover to more than 4.5. Otherwise an error message E11 will occur.

DYNAMIC RESPONSE CHECK AFTER WASH

Fig 5-5. Chemical cleaning of sensors

5-3-9. Test and setup mode

Code 80 *TEST The test mode is used to confirm the instrument setup. It is based on the factory setup procedure and can be used to check the QIC (factory generated test certificate). To use this test feature it is necessary to have the detail provided only in the QIS (Quality Inspection Standard) or the Service manual.

NOTE: attempting to change data in service code 80 and above without the proper instructions and equipment, can result in corruption of the instrument setup, and will impair the performance of the unit.

Code	Display	Function	Function detail	X	Y	Z	Default values
Test and setup mode							
80	*TEST	Test and setup	Built in test functions as detailed in QIS and Service Manual				

6. CALIBRATION

The EXA PH402 can be calibrated in three distinct ways.

6-1. Automatic calibration

This method uses internally programmed buffer tables, from Service Codes 24, 25 and 26, to calculate the buffer value at the actual temperature during the calibration. In addition, the stability of the reading is automatically calculated, and when the reading has stabilized fully automatic adjustments of slope and asymmetry are made. This eliminates the question of how long the operator should allow prior to adjustment. A menu driven prompt system conducts the operator through the simple, foolproof routine.

Default settings for the buffer solutions are the standard NIST (formerly NBS) recognised solutions “4”, “7” and “9”. These are known as primary buffers. They have a much better buffer capacity than the “commercial” or adjusted buffers. Yokogawa strongly recommends the use of these buffers to provide the best pH calibration.

6-2. Manual calibration

In this method, the operator decides on the actual value to enter. Manual calibration is most often used for single-point adjustment of the asymmetry potential, by comparison method.

Manual calibration can also be used to perform a full 2-point calibration with solutions other than the NIST buffers that are listed in the calibration tables. In this case, the solutions are applied sequentially as in the AUT CAL method, but the user determines the adjustment of reading and stability.

NOTE:
During manual calibration the temperature coefficient is still active. This means that the readings are referred to 25 °C. This makes grab sample calibration easy and accurate. However, if the manual calibration technique is used for buffer calibration, the temperature coefficient must be set to zero in maintenance mode in the “TEMP”routine (see chapter 5).

6-3. Sample calibration

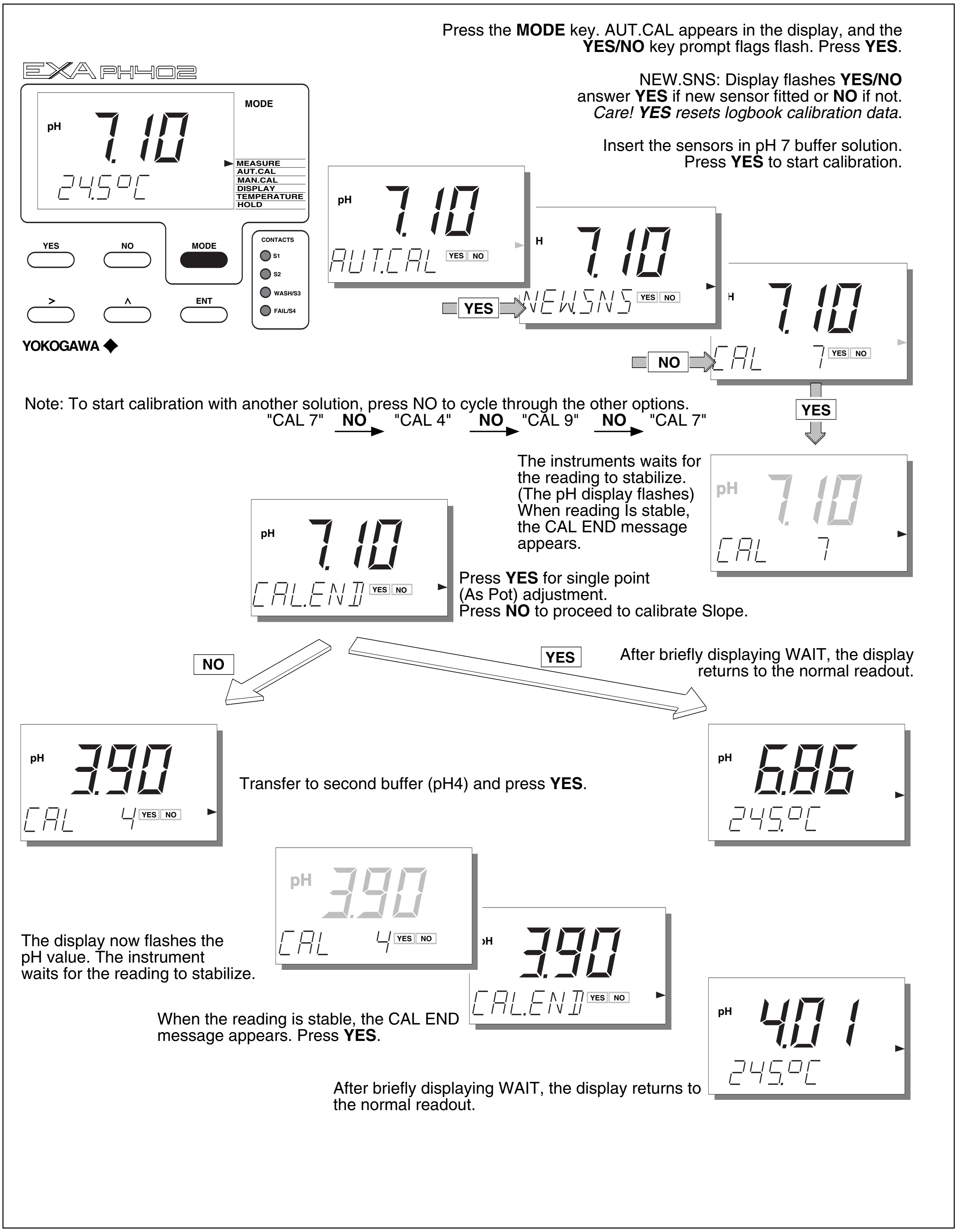
The operator activates the “SAMPLE” calibration routine, at the same time as taking a representative process sample. After determining the pH of this sample by independent methods, (in the lab for example) the reading can be adjusted. While the sample is being analyzed, EXA holds the sample data in memory, while continuing to control and read pH normally.

6-4. Data entry

In special circumstances, users can directly enter the calibration data in the service code menu (see chapter 5). This is appropriate where the manufacturer provides calibration data for each probe (as with the Pfaudler sensors) or where electrodes are laboratory calibrated for subsequent installation on the plant.
Service Code 23 allows the values of ITP, asymmetry potential (or zero point) and slope to be entered.

6-5. Calibration procedures

6-5-1. Automatic calibration

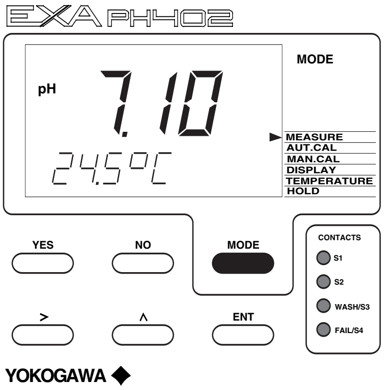


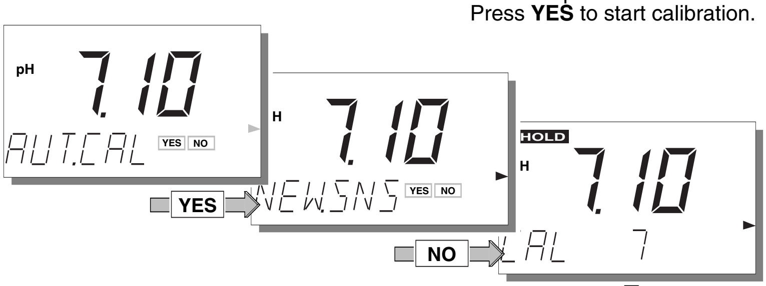
6-5-2. Automatic calibration with HOLD active

Press the **MODE** key. AUT.CAL appears in the display, and the **YES/NO** key prompt flags flash. Press **YES**.

NEW.SNS: Display flashes **YES/NO** answer **YES** if new sensor fitted or **NO** if not. *Care! **YES** resets logbook calibration data.*

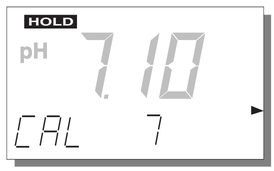
Insert the sensors in pH 7 buffer solution. Press **YES** to start calibration.





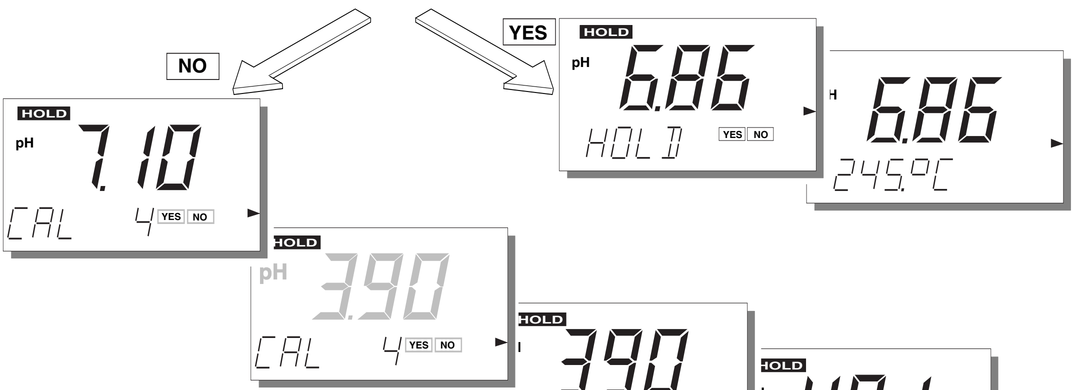
Note: To start calibration with another solution, press NO to cycle through the other options.
"CAL 7" **NO** → "CAL 4" **NO** → "CAL 9" **NO** → "CAL 7"

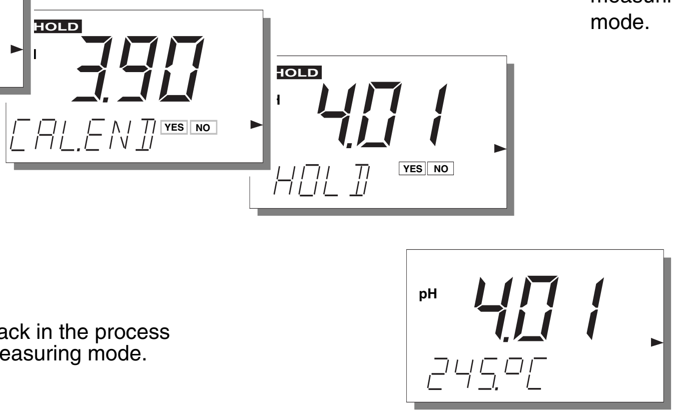
The instruments waits for the reading to stabilize. (The pH display flashes) When reading Is stable, the CAL END message appears.



Press **YES** for single point (As Pot) adjustment.
Press **NO** to proceed to calibrate Slope.

The single-point calibration is now complete. put sensors back in the process and press **NO** to switch off HOLD and return to measuring mode.





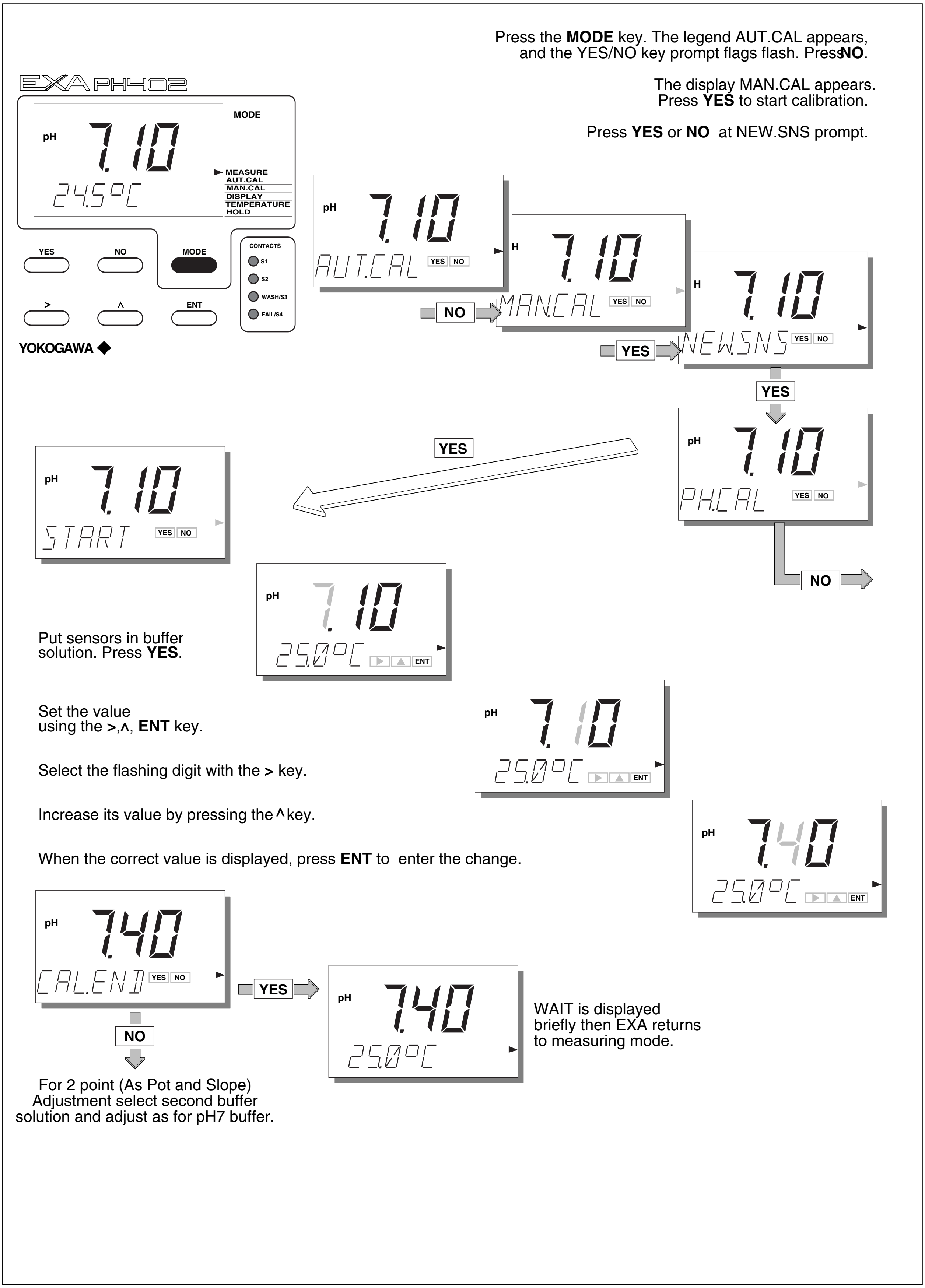
Transfer to pH 4 buffer and press **YES**.

The instrument then waits for the reading to stabilize. (The pH display flashes).

When the reading is stable, the CAL END message appears. Press **YES**.
WAIT flashes briefly then HOLD

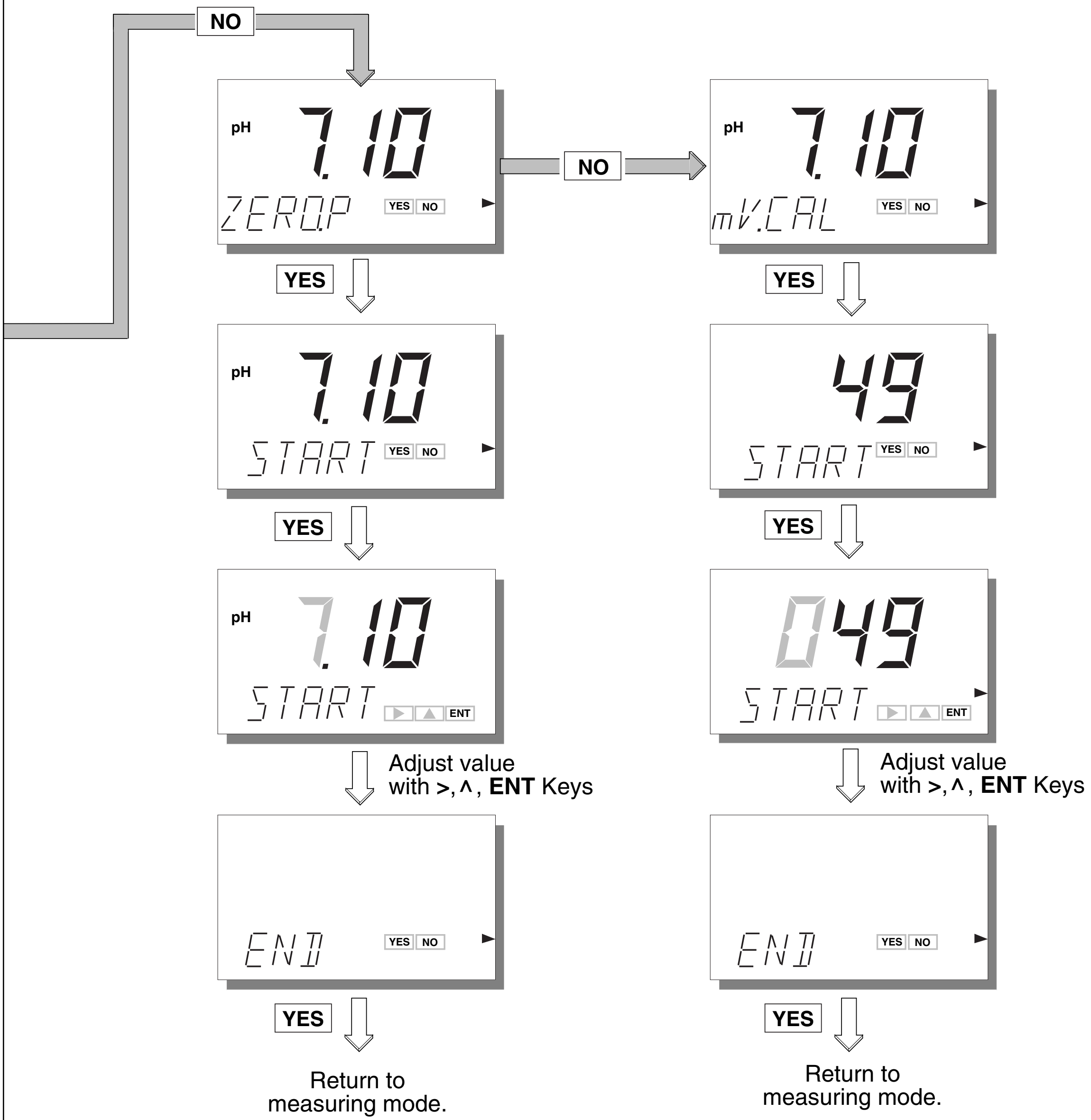
The calibration is now complete. Put the sensors back in the process and press **NO** to turn off HOLD and return to the measuring mode.

6-5-3. Manual calibration (2nd parameter calibration)



Manual Calibration of zero point according to IEC 746-2

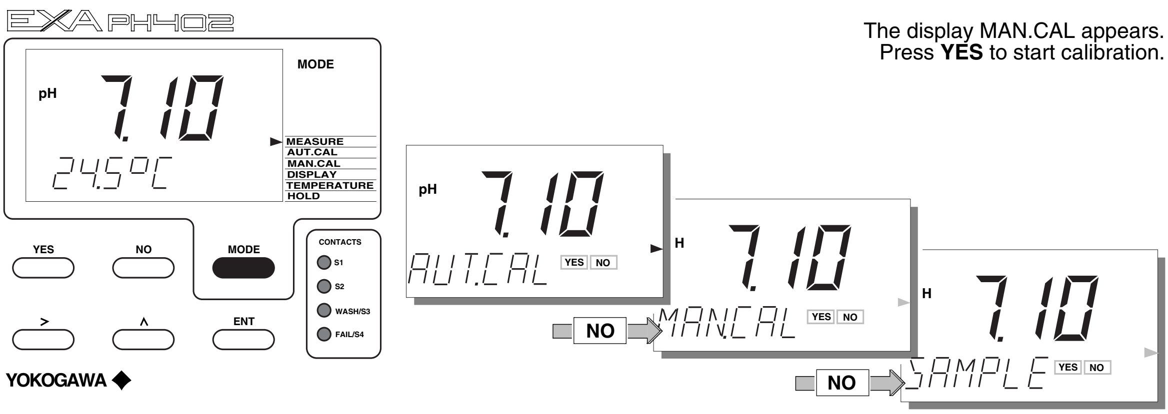
Manual Calibration of mV offset for ORP (2nd parameter). Where both pH and ORP (or rH) are measured, the offset (Asymmetry potential) of the second parameter is calibrated as shown below.

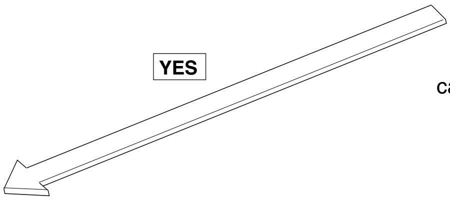


6-5-4. Sample calibration

Press the **MODE** key. The legend AUT.CAL appears, and the YES/NO key prompt flags flash. Press **NO**.

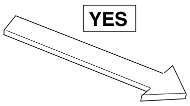
The display MAN.CAL appears. Press **YES** to start calibration.



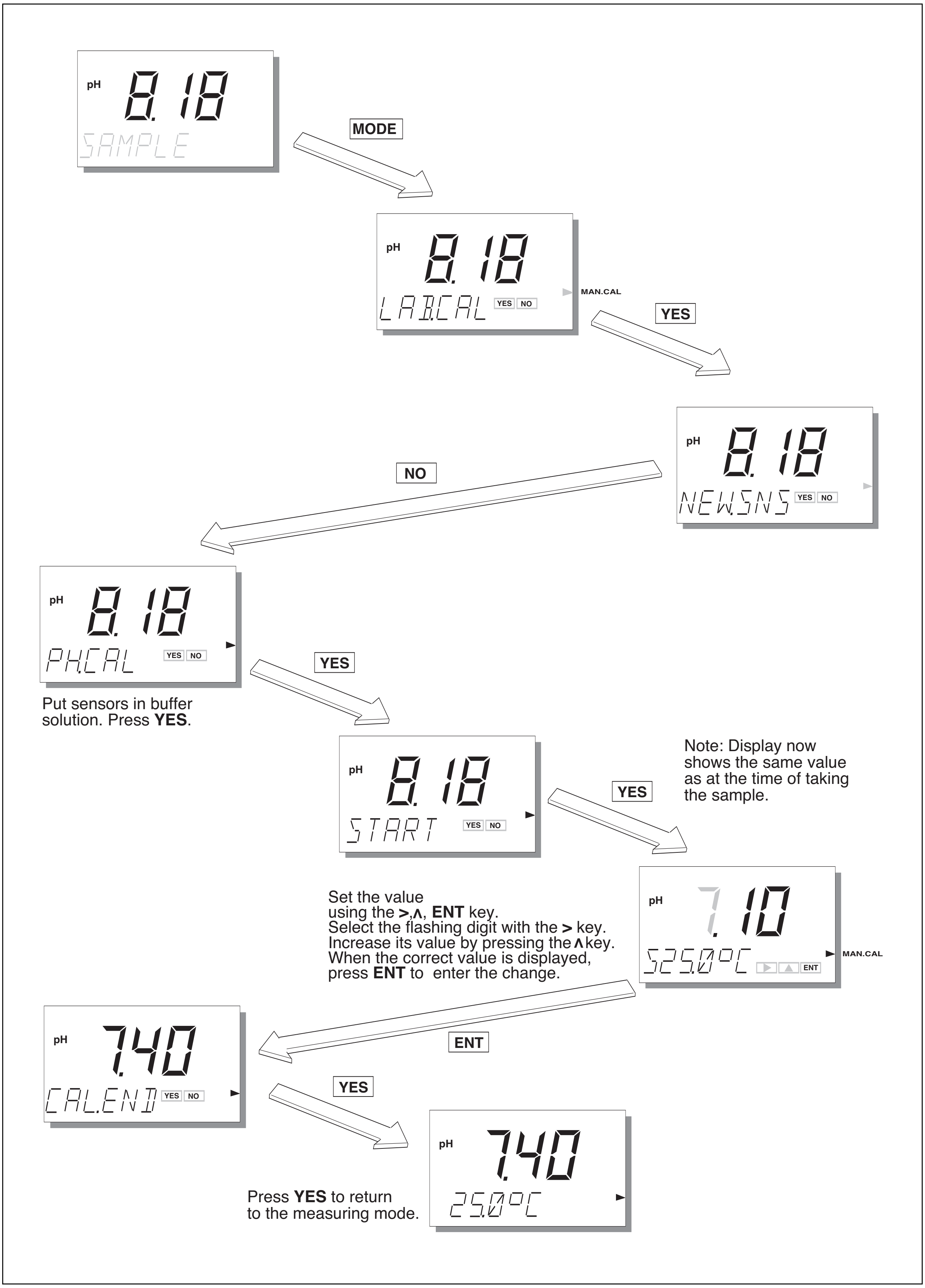


(Note: Press **NO** to start calibration of zero point when enabled in Service Mode).

Press YES at the same time as taking sample for analysis.



PH402 now continues to measure/control, as before. SAMPLE flashes to indicate that data is stored waiting for input of analyzed value.


pH 8.18
SAMPLE
MODE
pH 8.18
LAB.CAL YES NO
MAN.CAL
YES
pH 8.18
NEW.SNS YES NO
NO
pH 8.18
PH.CAL YES NO
YES
Put sensors in buffer solution. Press YES.
pH 8.18
START YES NO
YES
Note: Display now shows the same value as at the time of taking the sample.
pH 7.10
S25.0°C ENT
MAN.CAL
Set the value using the >,∧, ENT key.
Select the flashing digit with the > key.
Increase its value by pressing the ∧ key.
When the correct value is displayed, press ENT to enter the change.
ENT
pH 7.40
CAL.END YES NO
YES
pH 7.40
25.0°C
Press YES to return to the measuring mode.

7. MAINTENANCE

7-1. Periodic maintenance for the EXA PH402 converter

The PH402 transmitter requires very little periodic maintenance. The housing is sealed to IP65 (NEMA 4X) standards, and remains closed in normal operation. Users are required only to make sure the front window is kept clean in order to permit a clear view of the display and allow proper operation of the pushbuttons. If the window becomes soiled, clean it using a soft damp cloth or soft tissue. To deal with more stubborn stains, a neutral detergent may be used.

NOTE:
Never used harsh chemicals or solvents . In the event that the window becomes heavily stained or scratched, refer to the parts list (Chapter 9) for replacement part numbers.

When you must open the front cover and/or glands, make sure that the seals are clean and correctly fitted when the unit is reassembled in order to maintain the housing's weatherproof integrity against water and water vapor. The pH measurement uses high impedance sensors and may otherwise be prone to problems caused by exposure of the circuitry to condensation.

The EXA instrument contains a lithium cell to support the clock function when the power is switched off. This cell needs to be replaced at 5 yearly intervals (or when discharged). Contact your nearest Yokogawa service centre for spare parts and instructions.

7-2. Periodic maintenance for the sensor system

NOTE:
Maintenance advice listed here is intentionally general in nature. Sensor maintenance is highly application specific.

The sensor system must be kept clean to function well. This may require regular cleaning of the electrodes. (The effect of dirty electrodes will be to slow the system response and perhaps corrupt the measuring loop entirely). The frequency of cleaning and the method of cleaning will depend entirely on the process.

Where a refillable (flowing electrolyte) reference system is employed, make sure that the reservoir is kept topped up. The rate of electrolyte consumption will again be process dependent, so experience will show how often you must refill.

The periodic recalibration of the sensor system is necessary to ensure best accuracy. This takes into account the aging of the sensors, and the nonrecoverable changes that take place. These processes are slow, however. If frequent recalibration is needed, it is usually because the cleaning process is not effective, the calibration is not well executed or the pH readings are temperature dependent. Monthly calibrations should be sufficient for most applications.

If a film remains on the pH sensor after cleaning, or if the reference junction is partly plugged, then measuring errors can be interpreted as a need for recalibration. Because these changes are reversible with correct cleaning and/or proper selection or adjustment of the electrolyte flow through the junction, make sure that these items are correct before recalibrating the system.

Calibration procedures are described in step-by-step detail in chapter 6. However, follow these guidelines.

1. Before starting a calibration, make sure the electrode system is properly cleaned so that electrodes are fully functional. They must then be rinsed with clean water to avoid contamination of the calibration solution.
2. Always use fresh buffer solutions to avoid the possibility of introducing errors from contaminated or aged solutions. Buffers supplied as liquids have a limited shelf life, especially alkaline buffers which absorb CO2 from the air.
3. Yokogawa strongly recommends NIST (primary) buffer standards in order to ensure the best accuracy and best buffer capacity is available. Commercially adjusted buffers (e.g. 7.00, 9.00 or 10.00pH) are a compromise as a standard, and are often supplied without the temperature dependency curve. Their stability will be much worse than for NIST solutions.

NOTE:
NIST (formerly NBS) buffers are available as consumable items from any Yokogawa sales office under the following part numbers:

6C232	4.01 pH at 25°C}	
6C237	6.87 pH at 25°C}	A box contains 5 packets of powder. Each makes a 200 ml solution.
6C236	9.18 pH at 25°C}	

6C231

pH/temperature relations	
0 °C	1.67
5 °C	1.67
10 °C	1.67
15 °C	1.67
20 °C	1.68
25 °C	1.68
30 °C	1.68
35 °C	1.68
40 °C	1.69
50 °C	1.71
60 °C	1.72
70 °C	1.74
80 °C	1.77
90 °C	1.79
95 °C	1.81

6C232

pH/temperature relations	
0 °C	4.00
5 °C	4.00
10 °C	4.00
15 °C	4.00
20 °C	4.00
25 °C	4.01
30 °C	4.01
35 °C	4.02
40 °C	4.03
50 °C	4.05
60 °C	4.06
70 °C	4.12
80 °C	4.16
90 °C	4.21
95 °C	4.24

6C234

pH/temperature relations	
0 °C	7.10
5 °C	7.07
10 °C	7.04
15 °C	7.02
20 °C	7.00
25 °C	6.98
30 °C	6.97
35 °C	6.96
40 °C	6.96
45 °C	6.95
50 °C	6.95
55 °C	6.96
60 °C	6.96
70 °C	6.97
80 °C	6.98
90 °C	7.00
95 °C	7.01

6C236

pH/temperature relations	
0 °C	9.46
5 °C	9.40
10 °C	9.33
15 °C	9.28
20 °C	9.23
25 °C	9.18
30 °C	9.14
35 °C	9.10
40 °C	9.07
50 °C	9.01
60 °C	8.97
70 °C	8.93
80 °C	8.91
90 °C	8.90
95 °C	8.89

6C237

pH/temperature relations	
0 °C	6.98
5 °C	6.95
10 °C	6.92
15 °C	6.90
20 °C	6.88
25 °C	6.87
30 °C	6.85
35 °C	6.84
40 °C	6.84
50 °C	6.83
60 °C	6.84
70 °C	6.85
80 °C	6.86
90 °C	6.88
95 °C	6.89

8. TROUBLESHOOTING

The EXA PH402 is a microprocessor-based analyzer that performs continuous self-diagnostics to verify that it is working correctly. Error messages resulting from faults in the microprocessor systems itself are few. Incorrect programming by the user can be corrected according to the limits set in the following text.

In addition, the EXA PH402 also checks the electrodes to establish whether they are still functioning within specified limits. The transmitter checks the glass-electrode impedance for a low value to determine if it is broken or cracked, and for a high impedance to check for internal breakage or disconnection.

The reference system is prone to more faults than the glass electrode in general. The unit measures the impedance value and compares it to the programmed value in memory to determine acceptance during testing. A high impedance signals pollution or poisoning of the reference electrode diaphragm.

Also, the EXA PH402 checks the electrodes during calibration to determine if the reaction time is suitable for pH measurement. A specially timed check can be activated following each cleaning cycle. After calibration, the unit checks the calculated asymmetry potential and the slope to determine if they are still within limits specified by the software.

The slow shift of asymmetry potential could signal a poisoning of the reference electrode system by the process. The decrease of slope equals a decrease of sensitivity of the glass electrode or can show a coating buildup at the electrode.

The EXA PH402 makes a distinction among diagnostic findings. All errors are signaled by the FAIL area in the display. Only faults in the measuring circuits activate the FAIL contact switching.

What follows is a brief outline of some of the EXA PH402 troubleshooting procedures, followed by a detailed table of error codes with possible causes and remedies.

NOTE:
The diagnostic function of the PH402 gives a variable time interval between impedance checks, up to 5 minutes. When trouble shooting, a manual impedance check can be initiated by following the procedure in section 5-1-6.

8-1. Diagnostics

8-1-1. Off-line calibration checks

The EXA PH402 transmitter incorporates a diagnostic check of the asymmetry potential after a calibration has been completed. This is a valid check for both manual and automatic calibration routines.

The actual value can be called up from the DISPLAY routine in the maintenance menu. A large value often indicates a poisoning or pollution of the reference system used. If the asymmetry potential exceeds programmable limits, the EXA PH402 generates an error (E2).

The EXA PH402 also performs diagnostics to check for the slope of the pH electrode after automatic calibration is completed. The actual value of the slope can be called up on the DISPLAY routine in the maintenance menu (SL). This value is an indication of the age of the electrode. If the value stays within the limits of 70 to 110 percent of the theoretical value (59.16 mV/pH at 25°C), it is accepted. Otherwise, the unit generates an error (E3).

Activation or deactivation of the asymmetry diagnostic check and slope check is made from the Service Codes. See Chapter 5 or Chapter 10 (Appendix).

8-1-2. On-line impedance checks

The EXA PH402 has a sophisticated impedance checking system. The sensors can be checked for their impedance over a very wide range, which makes the tool equally useful for glass, enamel, reference and metal (ORP) sensors. The measurement is temperature compensated for the characteristic of the pH glass sensor.

In order to measure accurately over such a wide range, it is necessary to split the range into two. This is done by a pair of jumper settings, high range and low range can be set on either input, making the system extremely flexible.

The following error message table gives a list of problems that are indicated when the high or low impedance limits are exceeded for a sensor. Such things as fouling, breakage and cable faults are readily detected. The non-immersion of the sensors in the process fluid is also signalled.

9. SPARE PARTS

Table 9-1. Itemized parts list

Item No.	Description	Part no.
1	Cover assembly including gasket and 4 fixing screws (M4 x 20)	K1541JG
2 *	Digital / display board	K1543DB
3	EPROM (programmed memory chip) + latest software	K1543BK
4	Protective cover for power terminal complete with fixing screw	K1541JH
5 *	Input and power board (230 VAC)	K1543PE
	Input and power board (115 VAC)	K1543PG
	Input and power board (100 VAC)	K1543PN
	Input and power board (24 VDC)	K1543PL
6	Fuse holder	K1543AA
7	EXA 402 case	K1541JJ
8	Fuse (box of 10 pieces) for 230 V AC (250 V AC, 50 mA, T)	K1543AK
	Fuse (box of 10 pieces) for 115 V AC and 100V AC (250 V AC, 100 mA, T)	K1543AL
	Fuse (box of 10 pieces) for 24 V DC (250 V AC, 1 A, T)	K1543AM
9	Cable gland set (one gland including seal and backing nut)	K1500AU
10	Flat cable	K1543AB
11	Securing screw set	K1543AC
12	Hingepin	K1543KS
13	Lithium cell (battery)	K1543AJ
14	RS485/232 Converter for communication to PC	K1543WM
Options		
/U	Pipe and wall mounting hardware	K1542KW
/PM	Panel mounting hardware	K1541KR
/SCT	Stainless steel tag plate	K1543ST

* NOTE: Contact your nearest Yokogawa service centre for the procedure for changing items 2 and 5.
(Re-initialisation of the instrument).

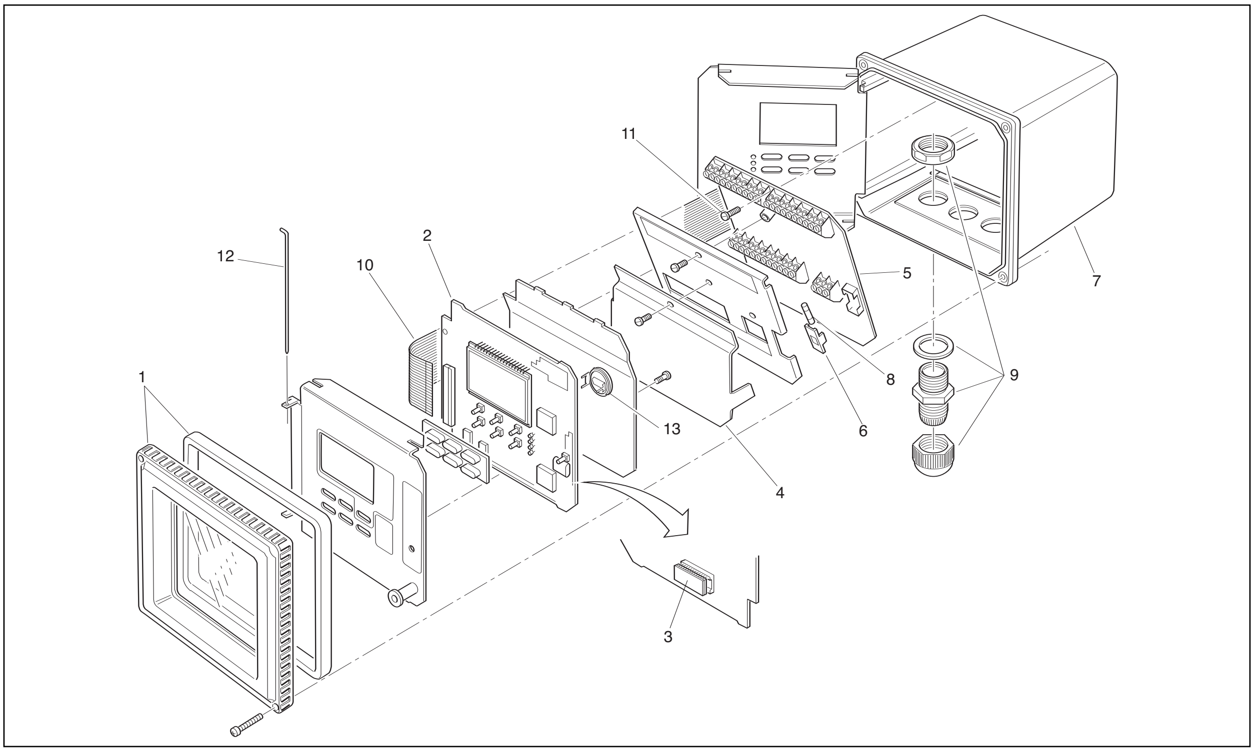


Fig. 9-1. Exploded view

10. APPENDIX

10-1. User setting table

	FUNCTION	SETTING DEFAULTS		USER SETTINGS		
Parameter specific functions						
01	*PH.ORP	0	pH			
02	*PRM2	0	Off			
03	*Z1.CHK	1.1.1	High range, TC on check on			
04	*Z2.CHK	0.0.1	Low range, TC off check on			
05	*CAL.CK	1.1	AP on, Slope on			
Temperature functions						
10	*T.SENS	0	Pt1000			
11	*T.UNIT	0	°C			
12	*T.ADJ		None			
13	*T.COMP *T.COEF	0 - 0.0	Off pH/10°C			
Calibration functions						
20	*Δt.SEC	5	Sec			
	*ΔpH	0.02	pH			
21	*AP.LOW	-120	mV			
	*AP.HI	120	mV			
22	*SL.LOW	70	%			
	*SL.HI	110	%			
23	*ITP	7.00	pH			
	*SLOPE	100.0	%			
	*ASP.1D	0.0	mV			
	*ASP.mV		mV			
24	*BUF.ID	4	NIST 4			
25	*BUF.ID	7	NIST 7			
26	*BUF.ID	9	NIST 9			
27	*ZERO,P	0	disabled			
mA outputs						
30	*mA	1.1	both 4-20mA			
31	*OUTP.F	0.2	pH (ORP) & Temp.			
	*D/R	0	Reverse (control)			
32	*BURN	0.0	both off			
33	*RG.mA2	prop band	only for PI control			
34	*tI.mA2	integ. time	only for PI control			
35	*TABL1	21 pt table	see code 31			
36	*TABL2	21 pt table	see code 31			

FUNCTION		SETTING DEFAULTS		USER SETTINGS		
Contacts						
40	*S1	2.0.0				
41	*S2	1.0.0				
42	*S3	4.0.0				
43	*S4	4.0.0				
44	*D.TIME	0.2	sec.			
	*PH.HYS	0.1	pH			
45	*RANGE	1	pH			
	*PER	10	sec			
	*FREQ	70	p/min			
46	*tI.CNT	100	sec			
47	*EXPIR	0	off			
	*tE	15	min			
User interface						
50	*RET	1	on			
51	*MODE	0.0	both off			
52	*PASS	0.0.0	all off			
53	*Err.4.1	1	hard fail			
	*Err.5.1	1	hard fail			
	*Err.4.2	1	hard fail			
	*Err.5.2	1	hard fail			
	*Err.07	1	hard fail			
	*Err.08	1	hard fail			
	*Err.09	1	hard fail			
	*Err.11	0	hard fail			
	*Err.16	0	hard fail			
	*Err.22	0	soft fail			
	*SOFT	0	LCD + Fail contact			
55	*CALL.M	0	250 days			
56	*DISP	1	0.01 pH			
Communication						
60	*COMM.	0.1	off/write prot.			
	*SET.	3.1	9600/odd			
	*ADDR.	00	00			
61	*HOUR	**set time**	**and date**			
62	*PASS	0.0.0	all off			
General						
70	*LOAD	**reset**	**defaults**			
71	*tH.CHK	0	off			
72	*W. REV	0	off			
79	*CUST.D					
Test and setup mode						
80	*TEST					

10-2. Configuration checklist for PH402G

	Standard Configuration	Options	Reference for change
Measured Variable(s)			
primary inputs	pH, ORP and Temp		
pH range	0-14 pH	any span within -2-16 pH	"range"
pH range linearized	disabled	21 point table	codes 31& 35
ORP range	-500 to 500 mV	spans up to 3000mV between -1500 to 1500mV	"range"
Temperature range	-30-140°C	any span over 25°C	"range"
Temperature unit	Celsius	Fahrenheit	code 11
mA Outputs			
analog output	4- 20 mA for pH	0- 20 mA or 4- 20 mA	code 30
second output	4- 20 mA for Temp	0- 20 mA or 4- 20 mA	code 30
output allocation	pH and Temp	pH, ORP, Temp, Table, PI cont	code 31
output linearization	disabled	pH/ORP	codes 35 & 36
Contact outputs			
contact outputs	S1= high at 14 pH S2= low at 0 pH S3= WASH S4= FAIL	(4) freely programmable	"setpoint" code 40. 41, 42, 43
contact allocation	pH & FAIL	pH, temp, ORP, rH, wash, PI control, HOLD, FAIL	code 40- 43
contact variables	dead time= 0.2 s; hyst= 0.1pH	time: 0- 200 s; hyst 0- 16 pH	code 44
add. contact functions	none	time out alarm	code 47
control functions	none	PI on contacts or mA output	code 45, 46, 34, 33
digital Outputs	none	RS485	code 60
Communication			
digital interface	disabled	RS485	code 60
communication software	external	PC402	contact factory
variables on display	pH and temp	pH, ORP, rH mA1, mA2, SL, AP, Z1, Z2 etc.	"display"
burn out	disabled	burn low (3.5)/ high (22) on mA1/ mA2	code 32
password protection	disabled	for maint/ comm./ serv level	code 52
autoreturn	return to measure in 10 min.	enable or disable	code 50
add. functions in MAINT	disabled	wash start/ setpoints/ Imp. chk. start	code 51
Diagnostics			
impedance checking	active	enable or disable	code 03 & 04
check on calibration data	active	enable or disable	code 05
check on stability	0.02 pH per 5 s	choose stability level	code 20
response check	disabled	enable or disable	code 71
man. imp. check	enabled	manual start	“maint”
Compatibility			
pH or ORP	glass sensor/metal electrode	pH or ORP	code 01
temperature sensor	Pt 1000Ω	Pt1000; Pt100, etc	code 10
other sensors	enamel sensors (Pfaudler)	impedance check setup	codes 03 & 04
2nd parameter	disabled	pH & ORP/ pH &rH	code 02
manual temp. comp.	disabled	disable or enable	"temp"
Special Features			
buffer table configuration	NIST standard	fully configurable	codes 24, 25 & 26
temperature calibration	none	adjustment +/- 20 °C	code 12
zero point calibration	disabled	disable or enable	code 27
sensor washing	disabled	interval 0.1 - 36 hours/time 0.1 - 10 min	“wash”
call for maintenance		set time interval 1 - 250 days	code 55
HOLD during maintenance		hold last or hold fix	“hold”
contact during HOLD		possible on S1, S2 or S3	code 40 - 42
process temp. compensation	disabled	set temperature coefficient	code 13
soft fail alarm	disabled	possible for E1 .. E9, E12, E22	code 53
logbook	disabled	2 x 50 events	code 61, 62

10-3. Setup for sensor compatibility

10-3-1. General

The inputs of the EXA transmitter are freely programmable for ease of installation. Standard glass pH electrodes, Ag/AgCl reference electrodes and Pt100 and Pt1000 temperature sensors need no special programming. The EXA indicates a fault with a signal in the display field if there is a mismatch of sensors in the connection.

10-3-2. Selection of measurement and reference electrode

The EXA PH402 is pre/programmed to accept industry standard glass electrodes and reference electrodes. The unit initiates checks for asymmetry and slope during calibration. The on-line impedance checking function has been upgraded in this most recent EXA release.

The EXA is universally compatible with all types of electrodes, such as enamel and antimony. In such systems, however, the specific isothermal point of intersection (ITP), slope (pH/mV) and asymmetry potential can be set for the type of electrode.

10-3-3. Selecting a temperature sensor

The EXA PH402 reaches its highest accuracy when used with the Pt1000 temperature sensor. This element offers a 10-fold increase in resistance dependence over the Pt100 sensor. Choice of temperature sensor is made in the Service Codes found in Chapter 5 and Chapter 10 (Appendix) of this manual.

- **ITP**
  Most Yokogawa sensor systems use an Iso-thermal point (ITP) of pH7 and a zero point at pH7. This is the default condition for which the transmitter is set. It is only necessary to consider this adjustment when installing a system with a different ITP. Antimony systems and Pfaudler probes are good examples of systems with different ITP values. Service code 23 is used. This also permits the setting of calibration data for precalibrated sensors.

- **Temperature sensor**
  The Pt 1000Ω RTD sensor is now becoming the most commonly used for temperature compensation. The transmitter accepts inputs from several different temperature sensors to suit most sensor systems. Service code 10-19 are used to set the temperature parameters and the process temperature coefficient.

- **Temperature calibration**
  For best accuracy, the temperature sensor should be calibrated to compensate for connection cable errors. See Service code 12.

- **pH Calibration**
  Traditionally, users select buffer solutions to suit the chosen output range. This is merely a continuation of the days of analog instruments that used indicators driven by the mA output. With digital technology, it is better to choose good buffer solutions and make an effective calibration than to use commercial (adjusted) buffers which may have round number values, but are less effective buffers with lower buffer capacity. It is for this reason that Yokogawa recommends that the NIST 4, 7 and 9 standard buffers be used to calibrate solutions. The temperature responses of these are pre-programmed into Service codes 24, 25, and 26 in the EXA PH402. Where other buffers are used with the semi-automatic calibration function, their temperature response should be programmed into the relevant code.

10-4. Setup for other functions

- **Contact Outputs**
  Alarms, trips, and proportional control are all possible with the relay outputs, and configuration is by Service codes 40-49. In addition, FAIL alarm and wash cycle controller are available.

- **Current outputs**
  Transmission signals for the measured parameters and control signals can be set up in service codes 30 to 39.

- **Wash cleaning**
  When used with the correct hardware, the EXA can control a wash cleaning system. Refer to service codes 40, 71 and 72.

- **Diagnostic Checks**
  Impedance checks, response time and stability checks are all included in the PH402. In order to get the best performance from each of these features, the converter should be fine tuned according to experience in the installation, and for the particular sensors selected. Service codes 3, 4, 5, 20 & 71 all contribute to the diagnostics. Please note that the default settings provide an excellent starting point and provide most valuable information about the performance of the electrode system.

- **Communications**
  The proprietary HART RS485 communication link allows remote configuration and data retrieval through the PC402 communication package. This is an excellent tool for the maintenance engineer, quality engineer or plant manager. Service codes 60-69 are used to set up the communications.

- **Logbook**
  In combination with the communications link, a “logbook” is available to keep an electronic record of events such as error messages, calibrations and programmed data changes. By reference to this log, users can easily evaluate diagnostic information to determine predictive maintenance schedules. For example, by monitoring the deterioration in the slope of the pH sensor, it can be changed before a failure (or process shutdown) occurs.

10-5. Set up for Pfaudler Type 18 sensor

The PH402 is intended to measure with all sorts of pH sensors, including the Pfaudler Type 18 sensor. The Pfaudler design of dual membrane system uses two enamels of differing sensitivity. The first a pH sensitive membrane, and the second one that responds to Na^{+} and K^{+} and acts as a reference.

The analyzer has dual high impedance inputs which measure perfectly even with very high impedance sensors. However, the impedance measuring system (diagnostics) needs to be set up for best performance.

10-5-1. General set up

1. Set impedance measuring hardware. This is done by the use of links on the terminals adjacent to the input terminals. For the Pfaudler system, this means that the terminals should have the links disconnected in order to set for HIGH/HIGH impedance measuring.

2. Set the impedance check in software. Use codes 03 & 04 to enable the measurement and set for high impedance and configure appropriate limits.

Code 03 set to 1.0.1	low limit	1 Megaohm
	high limit	1 Gigaohm
Code 04 set to 1.0.1	lowlimit	1 Megaohm
	high limit	1 Gigaohm

3. Set the temperature compensation sensor as 100 Ohm Platinum RTD with service code 10.

Code 10 set to 1	100 Ohms Pt.

The system will now respond properly to the Pfaudler type 18 sensor, and the other functions of the EXA analyzer will need to be set in the normal way to suit the use to which the loop is being put. Output ranges, control functions and alarms should all be set as described elsewhere in this manual.

10-5-2. Calibration set up

4. The alternative Zero point (calibration and display) according to IEC 746-2 may be enabled in service code 27, and set in the MAN.CAL routine. A value of 10.5 pH is a good starting point for the Pfaudler 18 sensor.

5. Where lab test data are available for the sensor, service code 23 can be used to set values for ITP & Slope (and As pot for parameter 2 when enabled).

(This method can be useful for the type 18 sensor, as it is not usual to perform regular calibrations on this system as with normal sensors. This is because the system may well respond differently, to ordinary buffers, than with the process solutions. The procedure is to determine the temperature response (ITP) and the sensitivity (Slope) of the sensor, and enter these values in code 23.)

Because this is a rather complex procedure, it is recommended instead to use the default settings of ITP = 7.00, and Slope = 100 %, and make a single point (MAN.CAL) calibration in the process at the working temperature, and at the normal operating (control setpoint) pH. This ensures that the desired control point will be measured accurately, even if there may be small deviations when there is a big deviation from the setpoint. This of course has no effect on the accuracy of a control loop. The special construction of the Pfaudler sensor ensures that there is practically no drift in the calibration. All that is necessary is to keep the sensor membranes clean. This is best done by cleaning with low pressure steam, which restores the original condition of the sensor, including the original calibration values.

10-6. Software history

Software changes of the PH402

• Changes made by software release 1.1

- In the PH402 the limits for the impedance measurement can be set-up in service-code 3 and 4. When the measured impedance value goes beyond these limits, an impedance to low/high error is generated and the Set-up limit value is displayed. More convenient is to measure beyond these limits and show the measured value all the time.

• Changes made by software release 1.2

- When was function is started automatically, at the end of the wash function the question HOLD yes/no was displayed and the instrument was waiting 10 minutes in HOLD. In release 1.2 the HOLD is automatically switched off after the wash function is completed.
  When the hardware limits for the impedance measurements are reached, the text Z1/2.LOW/HIGH is displayed instead of displaying the limit value.
  Reset problem during 3rd pH-buffer programming (SC26) is solved.
  In case of pH device with second parameter ORP-measurement enabled (SC02), the instrument returned with an inverted ORP value. Calculation updated in this release.
  New temperature sensors are added (in combination with a future new analog board). Hence the initialization procedure for PH402 is changed starting with software 1.2

• Changes made by software release 1.3

- Normally an E20 error indicates that programmed data is lost and no longer valid.
  In software versions 1.0, 1.1 and 1.2 an E20 error might occur wrongly; the contents of the EEprom is still correct.This error happened arbitrary just after starting up the PH402. The reason is a software bug which is solved in version 1.3 .

The next features are added concerning mA1/2 output and contacts 1..4:

-mA2:	PI control is now also available on ORP of 2nd parameter; this used to be available only for rH.
-mA1:	linear output on 2nd parameter is transferred from the menu of mA2 output to the menu of mA1 output.
-Contacts 1..4:	alarm is now also available on ORP of 2nd parameter; this used to be available only for rH. PI control is now also available on ORP of 2nd parameter; this used to be available only for rH.

After every wash cycle an impedance measurement will be performed now.

• Changes made by software release 1.4

- If something goes wrong during autocalibration or manual calibration, an E0, E1, E2 or E3 error will be generated. In software release 1.3 and below, the error was set as a soft fail error which could only be cleared by a new, correct calibration. In version 1.4 the error is displayed as a message only; after pressing the YES,NO or MODE key, the error message will be erased.
- The rH calculation was wrong in version 1.3 and below, because of a polarity fault. In release 1.4 it has been corrected.
- An E12 error indicates that the second process value (ORP/rH) exceeds its limits. In version 1.3 and below, the E12 error could be generated even when the second process value was disabled.
  In release 1.4, no E12 error will occur anymore if the second parameter is disabled.
- In release version 1.3 and below, scrolling through logbook was only available when pincode was installed. In release 1.4 logbook scrolling is always available, independent of pincode.
- Upgrading of communication software.

• Changes made by software release 1.5

In release 1.3 sometimes a spike on the current output occurs. The repetition rate is very low (each week once or twice) and irregular. In release 1.5 this problem is solved.
REMARK: this new version is based on release 1.3 and therefore does not have the functionality of release 1.4.

• Changes made by software release 1.6

- In version 1.6 the new functions of 1.4 and 1.5 are combined.

• Changes made by software release 1.7

- The software version 1.7 for the PH402 is functional identical to the software version 1.6, only small software changes for production improvement have been done.

• Changes made by software release 1.8

- The rH calculation was incorrect. There was a sign-error in the calculation formula. Also a 304mV offset voltage has been added in the calculation to make it right for a modern sensor. The rH calculation is correct now for a pH sensor with a buffer solution of pH 7 and an Ag/AgCl/KCl reference system. The old calculation was based on a sensor with a buffer solution of pH 1 (with HCl reference system).
- The instrument locked up when entering a wrong password.
- When manual temperature is active and HIF is entered, the manual value is showed for all temperature sensors.
- To improve EEPROM integrity the PEN (Program Enable) Pin is only enabled when there is an write-command to the EEPROM
- Sample calibration is not correct when the Temp. Comp. <> 0. The offset due to the T.C. is wrongly processed as a calibration correction.

• Changes made by software release 1.9

- Sensor check is switched OFF now during the start of CAL to prevent an unclear situation for the customer.

• Changes made by software release 2.0

- Service code 79 added for loading all defaults except pH buffer tables.
- No longer PIN needed for PI, communication and logbook scrolling.
- Select in service code 53 to do/don't toggle the failcontact periodically in case of a softfail.
- Default *T.COEFF changed from 0.00 into -0.00.
- 10k PTC added

• Changes made by software release 2.1

- Bug fixed in configuring contact S4 as control contact.

• Changes made by software release 2.2

- E20 is cleared after the programmed data was recovered.

• Changes made by software release 2.3

- Prevent incorrect values in case open temperature input and manual temperature setting.

• Changes made by software release 3.0

- The maximum ORP span is set to 3000mV (was 2000mV).

• Changes made by software release 3.1

- Communication is enable as a factory default setting.

• Changes made by software release 3.2

- Added manual impedance check setting through HART command S1.
- Maximum value for high impedance setting raised to 2 GΩ.

GLOSSARY

pH (-log [H+])

This is a logarithmic function of the Hydrogen ion activity (concentration). This provides a quick indication of the acidic or alkaline behavior of a dilute solution. Normally measured on a scale of 0-14 pH where low numerical values are acidic (0 is approximately 1 Normal acid) and high numbers are alkaline (14 is approximately 1 Normal NaOH). The neutral point is pH 7.

Defined by Nernst in the following equation: E = Eo + RT/nF x Ln [H+]

E	= measured potential
R	= gas constant
T	= absolute temperature
n	= valence
F	= Faraday number
Ln	= Napierian logarithm
[H+]	= activity of the Hydrogen ion
Eo	= Reference potential

ORP

Oxidation reduction potential is a measure of oxidizing power of a solution. The greater the milliVolt value with a negative polarity, the greater the oxidizing power. Reducing power is indicated by positive values of mV.

rH

This is a composite value that indicates the oxidizing power of a solution compensating for the influence of the acid or alkaline components. The scale is 0-55 rH, where oxidizing solutions provide the highest readings.

Asymmetry potential

This is the difference between the isothermal point of intersection and the zero point.

Slope

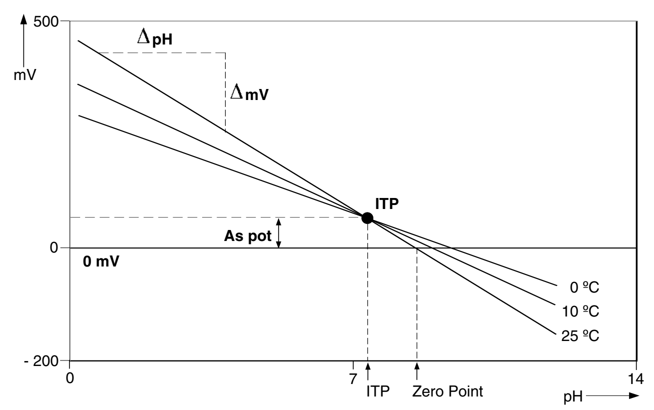
This is the sensitivity of the pH electrode (mV/pH) usually expressed as a % of the theoretical value (Nernst).

ITP

This is the isothermal point of intersection. This is the value in pH at which the temperature response of the system is at a null point. In other words, the point of intersection of the temperature lines on a graph of millivolts vs pH. This point is critical to the correct operation of the temperature compensation circuitry.

Zero point

This is the value of pH at which the electrode combination yields 0 mV as an output.



Error Codes

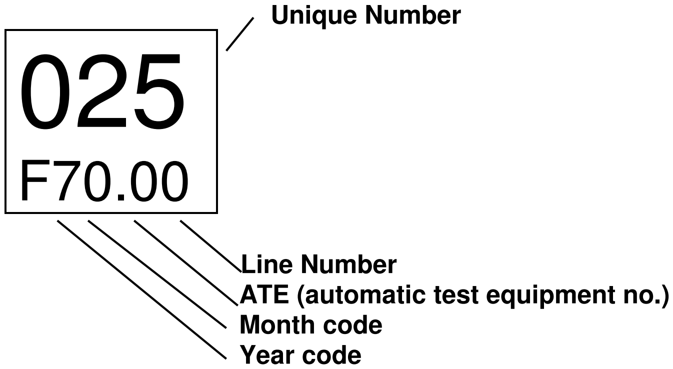
Code	Error description	Possible cause	Suggested remedy
E0	Buffer solution temperature outside the range 0- 50°C	Buffer solution too hot or too cold	Adjust buffer temperature Check cabling
E1	Measurement failed to stabilize . during the calibration	Sensors fouled Sensors too slow (aged sensor)	Clean sensors Replace sensors
E2	Asymmetry potential too high. (Limits set in service code 21.)	Sensors are aged or polluted Mistake in calibration	Check buffer solution Recalibrate at pH7 Replace sensor
E3	Slope (sensitivity) is outside limits. (Limits set in service code 22.)	Measuring sensor aged Poor insulation at the connector	Replace measuring sensor Replace or dry cables
E4.1	Impedance of input 1 too low. (Limits set in service code 03.)	Measuring sensor broken Damaged or damp connections	Replace measuring sensor Replace or dry cable
E4.2	Impedance of input 2 too low. (Limits set in service code 04.)	Reference sensor broken Damaged connections	Replace reference sensor Replace cables
E5.1	Impedance of input 1 too high. (Limits set in service code 03.)	Measuring sensor disconnected Sensors not immersed in process Liquid earth disconnected	Check connections Check process Check connections
E5.2	Impedance of input 2 too high. (Limits set in service code 04.)	Reference sensor fouled Liquid earth disconnected Insuffiicent electrolyte	Clean or replace sensor Check sensor immersion Check electrolyte reservoir
E7	Measured temperature too high>140 °C	Process too hot Wrong temperature sensor setting Temperature sensor damaged	Check process Check sensor & setting Check connections
E8	Measured temperature too low <-30 °C	Process too cold Wrong temperature sensor used Temperature sensor damaged	Check process Check sensor & setting Check connections
E9	Measurement out of range (-2 to 16 pH)	Sensors disconnected Sensor wrongly connected Sensor(s) defective	Check cabling Check cabling Replace sensor(s)
E10	EEPROM write failure	Fault in electronics	Try again, if unsuccessful contact Yokogawa
E11	Wash response time check failure. Half-value recovery time too long.	Measuring sensor aged Sensor still coated after washing Defective wash system	Replace measuring sensor Check cleaning system if needed adjust timings
E12	ORP / rH outside of preset limits	Sensors disconnected or wrongly connected	Check cabling
E14	No valid calibration data.	Data lost after switching from pH to ORP	Recalibrate
E15	Cable resistance to temperature sensor exceeds limits.	Cable resistance too high Corroded contacts Wrong sensor programmed	Use Pt1000Ω Clean and reterminate Reprogram
E16	Call for maintenance interval time exceeded.	System not maintained in preset time period	Perform maintenance Reset interval
E17	Output span too small <1pH or <50 °C/°F	Incorrect configuration by user	Reprogram
E18	Table values make no sense		
E19	Programmed values outside acceptable limits	Incorrect configuration by user	Reprogram
E20	All programmed data lost	Fault in electronics Very severe interference	Contact Yokogawa
E21	Checksum error	Software problem	Contact Yokogawa
E22	Alarm activation time exceeded	Process control not effective within set time.	Check control equipment Adjust value in code 47
E23	Zeropoint outside limits	Sensors are aged or polluted Mistake in calibration	Check buffer solution Recalibrate at pH7 Replace sensor

Quality Inspection Standard

EXA Series
Model PH402G
Converter for pH / ORP

1. Introduction

This inspection procedure applies to the model PH402 microprocessor based converter. There is a serial number, unique to the instrument which is stored in non-volatile memory. Each time the converter is powered up, the serial number is shown in the display. An example is shown below:



2. General

Final testing begins with a visual inspection of the unit to ensure that all the relevant parts are present and correctly fitted.

3. Insulation Test

During the production testing procedures, the insulation is tested between terminal 3, the supply earth, and power terminals 1 and 2. The test used applies the following criteria:
AC instruments - 2.1 kV DC, <1 mA, for >1 min.
DC instruments - 0.7 kV DC, <1 mA, for >1 min.
The outputs are also tested for isolation from earth ≥10 MΩ.

4. Accuracy Testing

The automated checks in service code 80 are used in this procedure. This automatically sets the output ranges to 0-14 pH and switches off the process temperature compensation. Temperature measurement is set to display in °C. Calibration data are also reset to 100% slope and 0 mV As. Pot. (Note: all setting are restored when the test mode 80 is completed.)
The test equipment needed is :

1. A resistance box of 0.1 Ω - 100 kΩ, accuracy 0.1% for temperature sensor simulation.
2. A 300 Ω resistor, accuracy 1% for mA output load resistor.
3. A millivolt source ranging from -1500 to +1500 mV with an accuracy of 0.1%.
4. A power supply to suit the converter (100 VAC, 115 /230 VAC or 24 VDC)
5. A mA meter with a range of 25 mA and an accuracy of 0.1% and a resolution of 1 µA.
6. A multimeter capable of measuring megohm ranges to check insulation impedance.
7. Screened cable to connect the input signals.
8. Single core flexible cable for liquid earth connection.

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Connect the PH402 as shown in Fig. 1. The resistance decade box to terminals 11 with the screen to terminal 12 to simulate the temperature input. Set decade box to simulate 25 °C, see tables below for the value for the selected sensor.
Connect the mV source to the input terminals, + (positive) to 15 with screen to 16, - (negative) to 13 with screen to 17, link terminal 14 to the negative terminal of the mV source.
Connect the output terminals through the 300 Ω load resistor to the mA meter. (Note: current outputs may be measured in turn with the same meter, or simultaneously if two meters and load resistors are available).

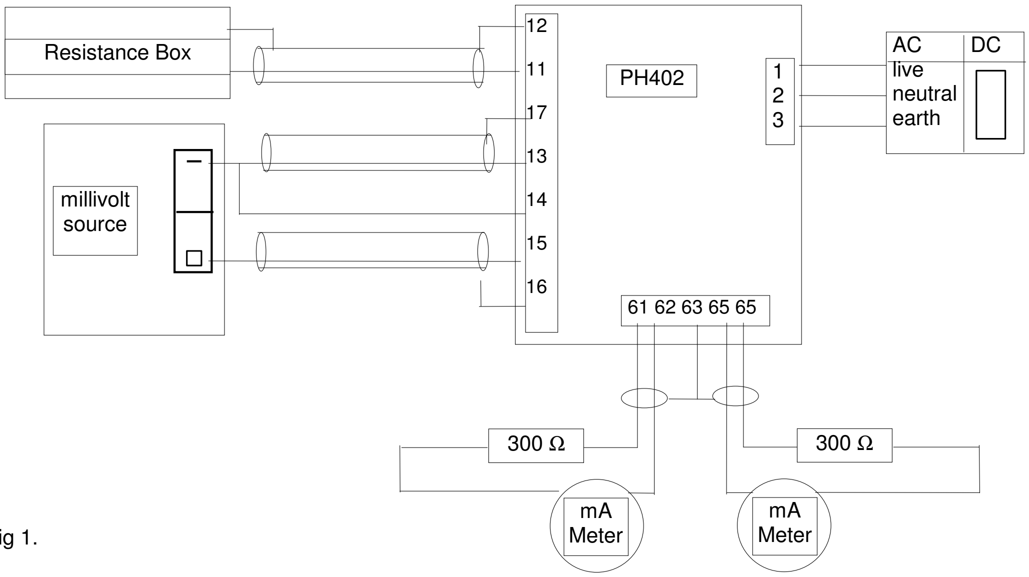

Fig 1.

4.1 Power On

After switching on the power to the unit, 5 minutes should be allowed for warm-up, and to stabilise the instrument completely before taking measurements.

4.2 Test Mode Entry

It is now necessary to proceed to 'code 80' in the service menu in order to check the calibration. See section 6 in the instruction manual

Press the button marked *	(*SETP) appears in the lower display
Press NO	(*RANGE) appears in the lower display
Press NO	(*HOLD) appears in the lower display
Press NO	(*WASH) appears in the lower display
Press NO	(*SERV) appears in the lower display
Press YES	(*CODE) appears in the lower display
Select code 80 and press ENT	(*TEST) appears in the lower display
Press YES	Go to test 4.3

4.3 Accuracy Test (ORP Display)

First set the mV source to the values listed below to simulate the ORP (mV) input and check the readings on the display.

Input	Display	Tolerance	Actual Display *
1500 mV	1500 mV	± 1 mV	*1501 mV*
750 mV	750 mV	± 1 mV	*750 mV*
0 mV	0 mV	± 1 mV	*0 mV*
-750 mV	-750 mV	± 1 mV	*-749 mV*
-1500 mV	-1500 mV	± 1 mV	*-1500 mV*

* *figures in italics are typical values shown for example only.*

Next vary the settings on the resistor decade box as listed below and check the temperature readings on the second row of the display.

4.3.1 Accuracy Test (Temperature Display with Pt 100Ω RTD)

Resistance	Temperature	Tolerance	Actual Display *
92.2 Ω	-20 °C	± 0.4 °C	*-20.0 °C*
109.7 Ω	25 °C	± 0.4 °C	*25.1 °C*
129.0 Ω	75 °C	± 0.4 °C	*75.1 °C*
149.8 Ω	130 °C	± 0.4 °C	*130.0 °C*

4.3.2 Accuracy Test (Temperature Display with Pt1000 RTD)

Resistance	Temperature	Tolerance	Actual Display *
921.6 Ω	-20 °C	± 0.3 °C	*-20.0 °C*
1097.4 Ω	25 °C	± 0.3 °C	*25.1 °C*
1290.0 Ω	75 °C	± 0.3 °C	*75.1 °C*
1498.3 Ω	130 °C	± 0.3 °C	*130.0 °C*

4.3.3 Accuracy Test (Temperature Display with 3kΩ Balco Sensor)

Resistance	Temperature	Tolerance	Actual Display *
2406 Ω	-20 °C	± 0.3 °C	*-20.0 °C*
3000 Ω	25 °C	± 0.3 °C	*25.1 °C*
3660 Ω	75 °C	± 0.3 °C	*75.1 °C*
4386 Ω	130 °C	± 0.3 °C	*130.0 °C*

4.3.4 Accuracy Test (Temperature Display with 5k1Ω Sensor)

Resistance	Temperature	Tolerance	Actual Display *
4273.8 Ω	-20 °C	± 0.3 °C	*-20.0 °C*
5100.0 Ω	25 °C	± 0.3 °C	*25.1 °C*
6018.0 Ω	75 °C	± 0.3 °C	*75.1 °C*
7027.8 Ω	130 °C	± 0.3 °C	*130.0 °C*

4.3.5 Accuracy Test (Temperature Display with 8k55Ω Sensor)

Resistance	Temperature	Tolerance	Actual Display *
47000 Ω	-10 °C	± 0.3 °C	*-10.0 °C*
8550.0 Ω	25 °C	± 0.3 °C	*25.1 °C*
1263.0 Ω	75 °C	± 0.3 °C	*75.1 °C*
343.0 Ω	120 °C	± 0.3 °C	*119.9 °C*

4.3.6 Overall Accuracy Test

Still with the equipment setup as before, measure the current outputs with the following settings and confirm agreement with the table below.

Input	Display	Tolerance	Actual Reading *	Nominal mA 0-20	Nominal mA 4-20	Tolerance mA	Actual mA1 *	Actual mA2 *
414.1 mV	0.00 pH	± 0.01 pH	*0.01 pH*	0.00	4.00	± 0.06	*4.00*	*4.00*
177.5 mV	4.00 pH	± 0.01 pH	*4.01 pH*	5.71	8.57	± 0.06	*5.72*	*8.58*
0 mV	7.00 pH	± 0.01 pH	*7.00 pH*	10.00	12.00	± 0.06	*12.01*	*12.00*
-177.5 mV	10.00 pH	± 0.01 pH	*9.99 pH*	14.29	15.43	± 0.06	*14.28*	*15.42*
-414.1 mV	14.00 pH	± 0.01 pH	*14.00 pH*	20.00	20.00	± 0.06	*20.00*	*20.00*

The tolerances specified relate to the performance of the PH402G in the controlled environment of the testing facility. Production testing is carried out in combination with specially calibrated automatic test equipment (ATE). In the field, the accuracy and linearity of the test equipment affects the error in the reading. As much as an additional 0.1 mA may be seen in the mA output readings.

After completing these tests Press ENTER. This automatically starts the next test.

5. Accuracy & Linearity Check mA output circuits

This test is automatically generated in service code 80. Step through this test by repeatedly pressing ENTER.

Simulated Output	Tolerance mA	Actual Output 1 mA *	Actual output 2 mA *
0.0	± 0.02	*0.00*	*0.00*
4.0	± 0.02	*4.01*	*4.00*
8.0	± 0.02	*8.01*	*8.01*
12.0	± 0.02	*11.99*	*12.01*
16.0	± 0.02	*16.01*	*15.99*
20.0	± 0.02	*20.00*	*20.01*
22.0	± 0.02	*22.01*	*21.99*

This test is completed when the Display reads (*S1).

6. Relay Operation Check

This test is also automatically generated in service code 80.
> Key is used to select the relay to be tested. S1, S2, S3 or S4.
^ Key is used to toggle between ON /OFF states of the relay chosen.
ENT Key is used to exit this test mode.

Relay Number	Actual *
S1	*OK*
S2	*OK*
S3	*OK*
S4	*OK*

7. Communication Check

Press ENT (*COMM) is displayed.
The PH402G generates a message to confirm function of the RS485 communication. Specialised equipment is needed for this test. This test is not normally performed in the field.

Note

The testing of the PH402G is carried out under controlled environmental conditions. The end user may well find that his ambient conditions vary considerably from the ones noted in this certificate. In this case it is necessary to refer to the General Specification sheet for the details of ambient temperature drift etc.

* Values in *italics* are shown for example only.

QIS 12B6B3-E

Quality Inspection Certificate

EXA Series
Model PH402G
Converter for pH/ORP

1. Instrument Description

Model :	Serial No. :
Order :	Release Version :

2. General

OK

3. Insulation Test

OK

4.3 Accuracy Test (ORP Display)

Input	Display	Tolerance	Actual Display
1500 mV	1500 mV	± 1 mV	mV
750 mV	750 mV	± 1 mV	mV
0 mV	0 mV	± 1 mV	mV
-750 mV	-750 mV	± 1 mV	mV
-1500 mV	-1500 mV	± 1 mV	mV

4.3.1 Accuracy Test (Temperature Display with Pt 100Ω RTD)

Resistance	Temperature	Tolerance	Actual Display
92.2 Ω	-20 °C	± 0.4 °C	°C
109.7 Ω	25 °C	± 0.4 °C	°C
129.0 Ω	75 °C	± 0.4 °C	°C
149.8 Ω	130 °C	± 0.4 °C	°C

4.3.2 Accuracy Test (Temperature Display with Pt1000Ω RTD)

Resistance	Temperature	Tolerance	Actual Display
921.6 Ω	-20 °C	± 0.3 °C	°C
1097.4 Ω	25 °C	± 0.3 °C	°C
1290.0 Ω	75 °C	± 0.3 °C	°C
1498.3 Ω	130 °C	± 0.3 °C	°C

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4.3.3 Accuracy Test (Temperature Display with 3kΩ Balco Sensor)

Resistance	Temperature	Tolerance	Actual Display
2406Ω	-20 °C	± 0.3 °C	°C
3000Ω	25 °C	± 0.3 °C	°C
3660Ω	75 °C	± 0.3 °C	°C
4386Ω	130 °C	± 0.3 °C	°C

4.3.4 Accuracy Test (Temperature Display with 5k1Ω Sensor)

Resistance	Temperature	Tolerance	Actual Display
4273.8Ω	-20 °C	± 0.3 °C	°C
5100.0Ω	25 °C	± 0.3 °C	°C
6018.0Ω	75 °C	± 0.3 °C	°C
7027.8Ω	130 °C	± 0.3 °C	°C

4.3.5 Accuracy Test (Temperature Display with 8k55Ω Sensor)

Resistance	Temperature	Tolerance	Actual Display
47000Ω	-10 °C	± 0.3 °C	°C
8550.0Ω	25 °C	± 0.3 °C	°C
1263.0Ω	75 °C	± 0.3 °C	°C
343.0Ω	120 °C	± 0.3 °C	°C

4.3.6 Overall Accuracy Test

Input	Display	Tolerance	Actual Reading	Nominal mA 0-20	Nominal mA 4-20	Tolerance mA	Actual mA1	Actual mA2
414.1 mV	0 pH	± 0.01 pH	pH	0.00	4.00	± 0.06		
177.5 mV	4 pH	± 0.01 pH	pH	5.71	8.57	± 0.06		
0 mV	7 pH	± 0.01 pH	pH	10.00	12.00	± 0.06		
-177.5 mV	10 pH	± 0.01 pH	pH	14.29	15.43	± 0.06		
-414.1 mV	14 pH	± 0.01 pH	pH	20.00	20.00	± 0.06		

The tolerances specified relate to the performance of the PH402. Production testing is carried out in combination with a specially calibrated sensor. In the field, the accuracy and linearity of the sensor and test equipment affects the error in the reading. As much as an additional 0.1 mA may be seen in the mA output readings.
After completing these tests Press ENTER. This automatically starts the next test.

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5. Accuracy & Linearity Check mA output circuits

Simulated Output	Tolerance mA	Actual Output 1 mA	Actual output 2 mA
0.0	± 0.02		
4.0	± 0.02		
8.0	± 0.02		
12.0	± 0.02		
16.0	± 0.02		
20.0	± 0.02		
22.0	± 0.02		

6. Relay Operation Check

Relay Number	Actual
S1	**OK**
S2	**OK**
S3	**OK**
S4	**OK**

Date:	Ambient Temperature °C / Humidity %RH
Inspector: Signed:	Approved by: Signed:

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