Model 876EC Intelligent Electrochemical Transmitter for Electrodeless Conductivity Measurements with HART® Communications

Foxboro®

by Schneider Electric

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1. Introduction

The 876EC Electrodeless Conductivity Transmitter converts conductivity or concentration measurements to a 4 to 20 mA output signal with a superimposed HART digital signal for remote configuration and monitoring. A human machine interface is integral to the device and provides simplified menu-driven configuration, calibration, status, and diagnostic procedures.

A unique feature of this transmitter is that you can save up to two complete configuration programs and restore them at any time to facilitate a quick and easy change of the transmitter to a pre-saved configuration.

Reference Documents

The following documents provide additional and related information.

Document	Description
DP 611-260	Dimensional Print - 876PH, 876EC, and 876CR Transmitters
MI 611-206	Instruction - Intrinsically Safe Connector Diagrams and Nonincendive Circuits
MI 611-208 (a)	Instruction - Electrochemical Products Safety Information
PL 611-260	Parts List - 876PH, 876EC, and 876CR Transmitters

a. Available in many languages via our website. For help downloading this document contact our Global Customer Support Center.

Factory Default Passcode

The factory default passcode for both the Administrator and User is `0800`.

2. Quick Start

The purpose of this section is to:

♦ Help you wire your transmitter

♦ Familiarize you with the instrument configuration as received from the factory

♦ Assist you in verifying that your transmitter is in calibration

♦ Explain normal operation in Measure mode.

Wiring

⚠ **WARNING**

Wiring installation must comply with existing local regulations.

⚠ **WARNING**

For agency requirements, also see MI 611-206 (FM, CSA, and IECEx) or MI 611-208 (ATEX).

NOTICE

To minimize RFI/EMI effect, use grounded metal conduit on the sensor cable and input power leads.

Your 876EC Transmitter is a 2-wire transmitter. As such, it transmits output over the same two wires through which it receives power. Connect this power/output signal to the power terminals at the left of the printed wiring board inside the faceplate of your transmitter and the signal from your measurement sensor to the appropriate terminals at the top of the printed wiring board.

To access these terminals, remove the four captive screws in the corners of the bezel/keypad and open the hinged bezel/keypad downward.

NOTICE

The bezel/keypad does not open a full 180°. Do **not** press on it while wiring.

Figure 1. Wiring Connections for 876EC Transmitter
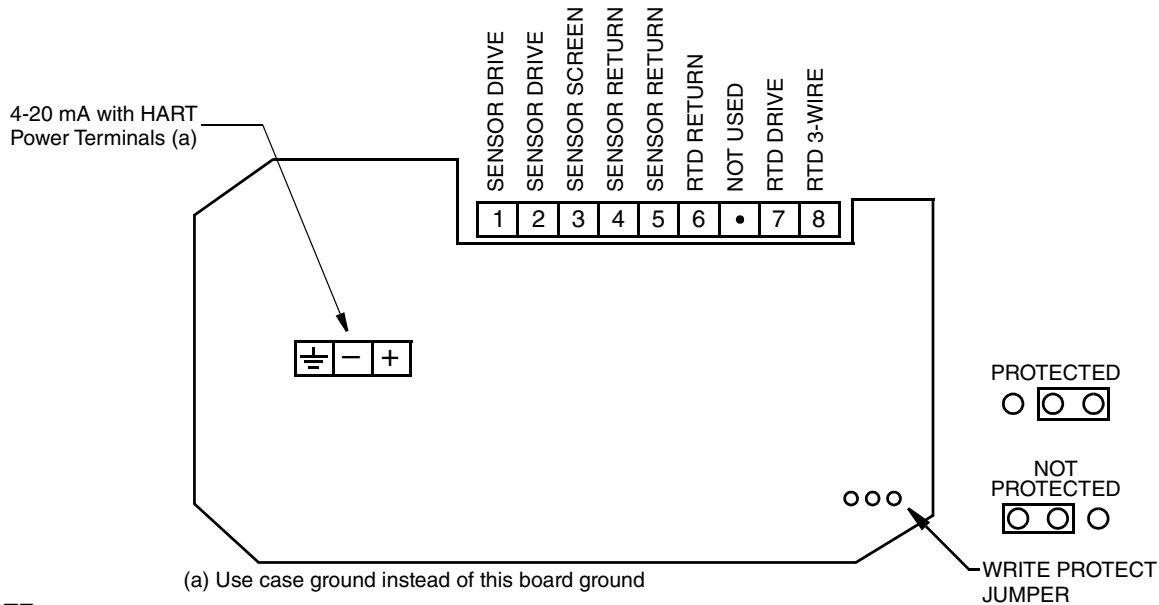
(a) Use case ground instead of this board ground

NOTE:
There must be at least 250 ohms total resistance between the PC-based configurator or HART communicator and the power supply.

Checking Factory Configuration

In Configuration mode, following the structure diagrams in Appendix C, "Configuration Structure Diagrams" and using the arrow keys, you can step through the product structure as configured in the factory. The factory default values are listed in Appendix D, "Configuration Table". The values in your transmitter may differ from these because your transmitter may have been configured at the factory to your specific requirements. In the table that comprises Appendix D, "Configuration Table", there is a column provided to make any notations you wish about your specific configuration.

To enter the Configuration mode, press the `Function` key and then the `Config` key. At the prompt, enter the passcode and press `ENTER`.

> **NOTE**
> The factory default passcode for both the Administrator and User is 0800.

Calibration

After wiring your transmitter and checking/changing the configuration, you should perform a 2-Point Manual calibration using the actual sensor for this application.

> **⚠ CAUTION**
>
> Due to variations between sensors, the transmitter should always be calibrated with the actual sensor for the application in order to ensure that the system performs with optimum accuracy.

1. Enter the calibration mode by pressing the `FUNCTION` key and then the `CAL` key.

2. At the prompt, enter the passcode and press `ENTER`.

3. If desired, enter information in the Calibrated By, Calibration Day, Calibration Month, and Calibration Year fields. Recording this information is not mandatory, but doing so will allow you to keep track of when the instrument was last calibrated and who performed the calibration.

4. Select `Measurement` from the Calibrate screen and follow the prompts for a 2-point manual calibration with resistors wired through the sensor to calibrate your transmitter.

5. At the end of a successful calibration, there should be no faults in the transmitter.

Basic Operation in Measure Mode

Measure is the normal operating mode of your transmitter. One, two, or three measurements can be displayed depending on the configuration. When the display is configured for single line measurements, the value and unit are usually displayed. Any measurement can be temporarily scrolled onto the display by using the `Up` and `Down` arrow keys. The display returns to the configured values when you press the `Function` key and then the `Measure` key or when the configured timeout period expires. When the transmitter is in Hold mode, a `Hold` indication appears in the upper right of the title bar. If there is a fault, a flashing fault symbol is displayed. If in Measure, Status, or Diagnostic mode, the word `FAULT` also flashes in the lower left of the display. When you press the `Function` key, the function indicator is displayed.

Figure 2. Sample 3-Line Measurement Display
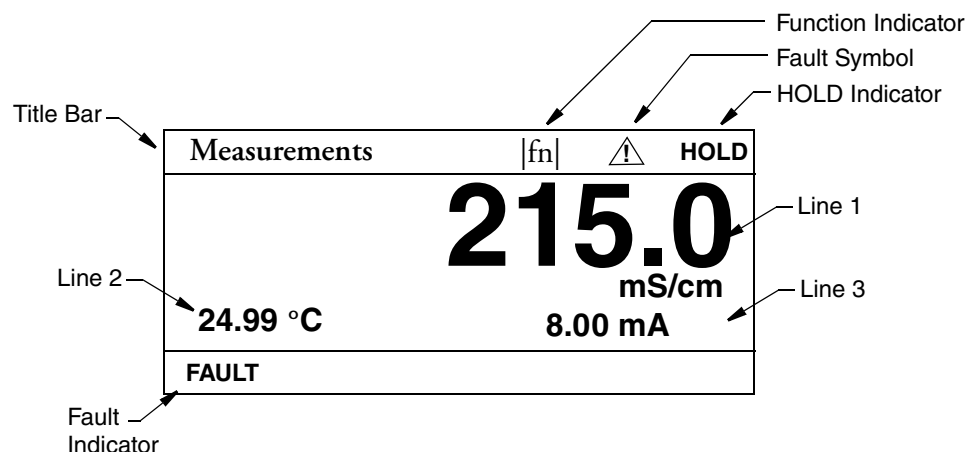
Looking for More Information?

For more detailed information, refer to the following sections of this manual:

♦ For detailed installation information, refer to "Installation" on page 19.

♦ For detailed explanation of the controls and indicators, refer to "Controls and Indicators" on page 25.

♦ For detailed configuration instructions, refer to "Configuration Mode" on page 50.

♦ For detailed calibration instructions, refer to "Calibration Mode" on page 34.

♦ For detailed operation from a HART Communicator, refer to "Operation Via HART Communicator" on page 71.

For dimensional information, refer to DP 611-260.

If you need additional help, contact Global Customer Support at 1-866-746-6477.

3. Specifications

Functional and Physical Specifications

Sensors: 871EC, 871FT, and FT10 Series Conductivity Sensors. Contact Global Customer Support for limitations and procedures with other electrically compatible sensors.

Temperature Compensation Inputs:

Factory precalibrated from -30 to +200°C (-22 to +392°F)

100 Ω platinum RTD; 2 or 3 wires

1000 Ω platinum RTD; 2 or 3 wires

100 k Ω thermistor (thermistor is limited from -20 to 150°C)

Solution Temperature: -30 to +200°C (-22 to +392°F)

Ambient Temperature:

Electronics: -30 to +70°C (-22 to +158°F)

Display: -30 to +70°C (-22 to +158°F)

Relative Humidity: 5 to 90% noncondensing

Environmental and Corrosion Resistant Protection: The enclosure has the dusttight and weatherproof rating of IP66 as defined by IEC 60529, and provides the environmental and corrosion resistant protection rating of NEMA 4X.

Electromagnetic Compatibility (EMC): The transmitter, when installed in accordance with MI 611-261, meets EMC directive 2004/108/EC by conforming to the following EN and IEC Standards:

♦ Radiated RF Immunity per IEC 61000-4-3

♦ Radiated RF Emissions per EN 55011:199

♦ Electrostatic Discharge per IEC 1000-4-2

♦ Switching and Indirect Lightning Transient (Surge) per IEC 1000-4-5

♦ High Frequency Transient per IEC 1000-4-4

♦ Conducted RF Immunity per IEC 61000-4-6

♦ Power Magnetic Field Effects per IEC 1000-4-8

Power Supply Requirements (for 4 to 20 mA output): 12.8 to 42 V dc (see Figure 8)

Load Limitations (for 4 to 20 mA output): 0 to 1300 ohms (see Figure 8)

Approximate Weight:

♦ Panel mounted: 3.1 kg (6.8 lb)

♦ Surface or pipe mounted: 3.7 kg (8.1 lb) including mounting bracket

Product Safety Specifications

> — **NOTE** ———————————————————————————————————
> The 876EC Transmitters have been designed to meet electrical safety descriptions
> listed in Table 1. For detailed information, or status of testing laboratory
> approvals/certifications, contact Global Customer Support.

Table 1. Product Safety Specifications

Testing Laboratory, Types of Protection and Area Classification	Application Conditions	Electrical Safety Design Code
ATEX II 1 G, Ex ia IIC Ga, intrinsically safe for Zone 0.	Temperature Class T4. Ta = -20 to 60°C.	AA
ATEX II 3 G, Ex ic IIC Gc, intrinsically safe for Zone 2.	Temperature Class T4. Ta = -20 to 60°C.	AN
CSA Ex ia IIC; intrinsically safe for Zone 0; and **CSA** intrinsically safe, Class I, II, III, Division 1, Gas Groups A, B, C, D, E, F, G.	Temperature Class T4. Ta = -20 to 60°C.	CA
CSA Ex nL IIC; energy limited for Zone 2; and **CSA** for Class I, II, III, Division 2, Gas Groups A, B, C, D, E, F, G.	Temperature Class T4. Ta = -20 to 60°C.	CN
FM/FMc AEx ia IIC; intrinsically safe for Zone 0; and **FM/FMc** intrinsically safe, Class I, II, III, Division 1, Gas Groups A, B, C, D, E, F, G.	Temperature Class T4. Ta = -20 to 60°C.	FA
FM/FMc AEx nC IIC; nonincendive for Zone 2; and **FM/FMc** nonincendive, Class I, II, III, Division 2, Gas Groups A, B, C, D, E, F, G.	Temperature Class T4. Ta = -20 to 60°C.	FN
IECEx Ex ia IIC Ga; intrinsically safe for Zone 0.	Temperature Class T4. Ta = -20 to 60°C.	DA
IECEx Ex nL IIC Gc; energy limited for Zone 2. and **IECEx** Ex ic IIC Gc; intrinsically safe for Zone 2.	Temperature Class T4. Ta = -20 to 60°C.	DN
NEPSI Ex ia IIC Ga; intrinsically safe for Zone 0.	Temperature Class T4. Ta = -20 to +60°C.	NA
NEPSI, Ex ic IIC Gc; intrinsically safe for Zone 2.	Temperature Class T4. Ta = -20 to +60°C.	NN
No certifications	N/A	ZZ

4. Installation

Unpacking

1. Remove the transmitter from the shipping container and check for visible damage.
2. Save the container until you determine that no shipping damage has occurred.
   a. If no damage is observed, proceed to the mounting procedure.
   b. If transmitter has been damaged, notify the carrier immediately and request an inspection report. Obtain a signed copy of the report from the carrier and contact Global Customer Support at 1-866-746-6477.

Identification

A data label is fastened to the left side surface of the enclosure. This label provides the model number and other information pertinent to your particular transmitter.

Figure 3. Sample Data Label

invensys		
Foxboro		
MODEL / ST	876EC-TWFA	A	— MODEL AND STYLE
SERIAL NO		— SERIAL NUMBER
CERT SPEC	FA	— ELECTRICAL CLASSIFICATION CODE
REF NO		— SALES ORDER NUMBER (IF APPLICABLE)
ORIGIN		— PLANT OF MANUFACTURE, DATE
SUPPLY	15.5 TO 42 VDC	— SUPPLY VOLTAGE
POWER	1 WATT MAX	— POWER CONSUMPTION
CALIB	0-200µs/cm	— MEASUREMENT RANGE
CONFIG CD		— COMMUNICATIONS
OUTPUT	4 - 20 mA	— mA OUTPUT
CUST DATA	STL09991	— USER INFORMATION

INVENSYS OPERATIONS MANAGEMENT
Country of Origin U.S.A.

Mounting

Panel Mounting

Panel mounting of the transmitter is shown in Figure 4.

1. Cut panel to receive instrument.
2. Insert screws in back of instrument.
3. Place instrument into panel and add bracket, washers and nuts from back side.

For panel cutout size, space requirements, and other dimensional data, see DP 611-260.

Figure 4. Panel Mounting

PANEL
TRANSMITTER
BRACKET
NUT
WASHER
SCREW
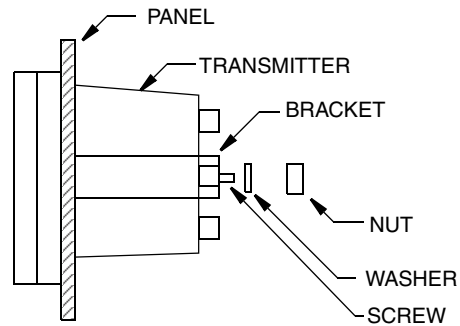
Surface Mounting

Surface mounting of the transmitter is shown in Figure 5.

1. Fasten mounting bracket to transmitter using screws, washers, and lockwashers provided.
2. Fasten mounting plate to surface using appropriate hardware.

For space requirements and other dimensional data, see DP 611-260.

Figure 5. Surface Mounting

LOCKWASHER
TRANSMITTER
BRACKET
SURFACE
CAP SCREW
WASHER
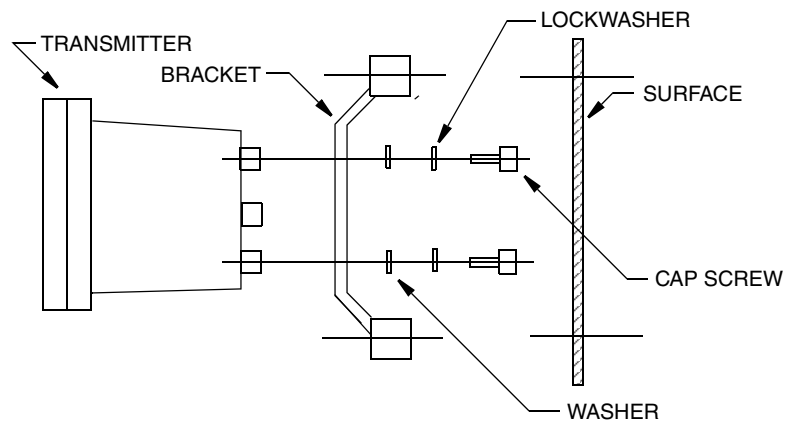
Pipe Mounting

Pipe mounting of the transmitter is shown in Figure 6.

1. Fasten mounting bracket to instrument using hardware provided.
2. Securely fasten mounting bracket to a DN50 or 2-in pipe with U-bolts supplied.

For space requirements and other dimensional data, see DP 611-260.

Figure 6. Pipe Mounting
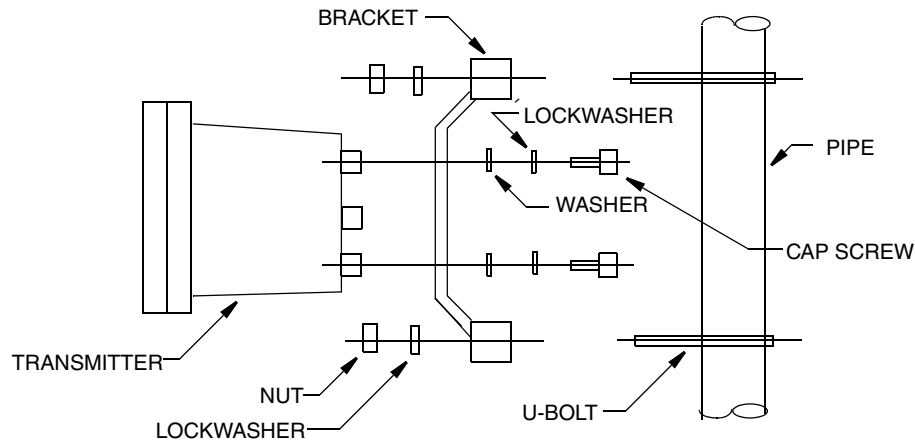
Wiring

Your 876EC Transmitter is a 2-wire transmitter. As such, it transmits output over the same two wires through which it receives power. Connect this power/output signal and the signal from your measurement sensor as described below.

⚠ **WARNING**

Wiring installation must comply with existing local regulations.

NOTICE

To minimize RFI/EMI effect, use grounded metal conduit on sensor cable and input power leads.

NOTICE

The bezel/keypad does not open a full 180°. Do **not** press on it while wiring.

1. Draw out the four screws on the corners of the faceplate and open the hinged door downward. Install proper fittings in the left and right ports in the bottom of the case.

Table 2. Recommended Conduit and Fittings

Material	Conduit	Fitting
Rigid Metal	1/2 inch Electrical Trade Size	T&B (a) #370
Semi-Rigid Plastic	T&B #LTC 050	T&B #LT 50P or T&B #5362
Semi-Rigid Plastic Metal Core	Anaconda Type HV, 1/2 inch	T&B #LT 50P or T&B #5362
Flexible Plastic	T&B #EFC 050	T&B #LT 50P or T&B #5362

a. T&B = Thomas & Betts Corp., 1001 Frontier Road, Bridgewater, NJ 08807

2. Bring your power wires in the left opening in the bottom of the case and attach to the power terminals at the left of the printed wiring board. See Figure 7.

3. Bring the sensor wires in the right opening in the bottom of the case and attach to the appropriate terminals at the top of the printed wiring board. See Figure 7.

—— **NOTE** ——
To maintain NEMA Type 4X and IEC IP66 protection, plug any unused openings with the plug, gasket, and locknut shown in PL 611-260.

4. Set the Write Protect jumper as shown in Figure 7.

Figure 7. Wiring Connections for 876EC Transmitter
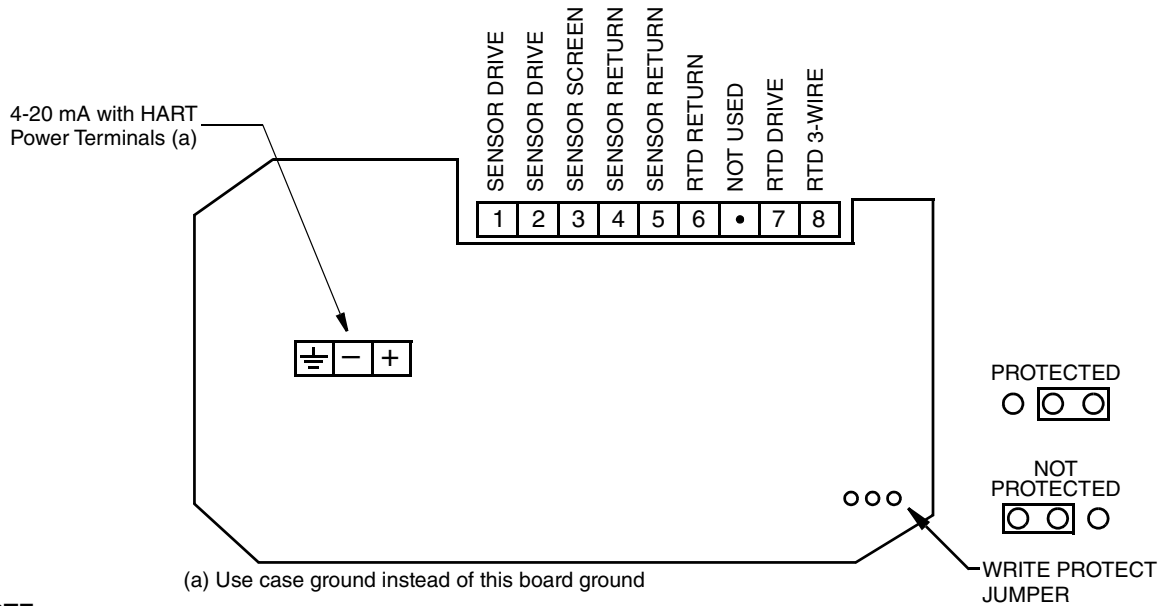
NOTE:
There must be at least 250 ohms total resistance between the PC-based configurator or HART communicator and the power supply.

Voltage Load Requirements

The voltage load requirements are given in Figure 8.

Figure 8. Supply Power and Loop Load
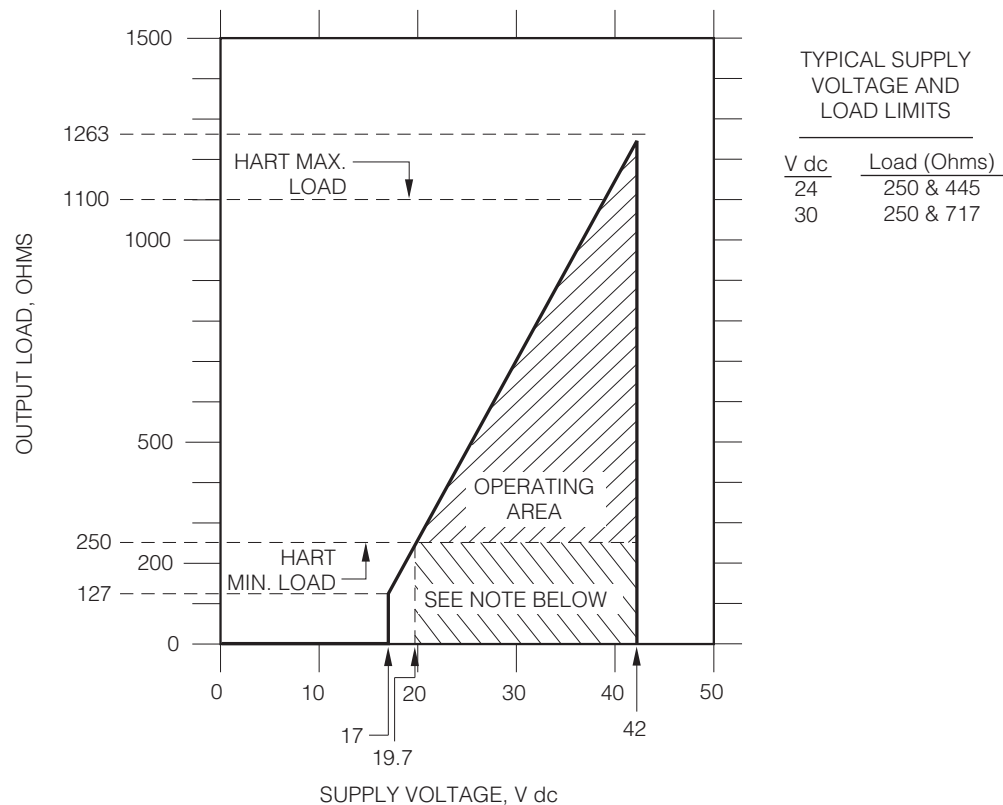
Examples:

1. For a loop load of 800 ohms, the supply voltage can be any value from 30 to 42 V dc.

2. For a supply voltage of 24 V dc, the loop load resistance can be any value from 0 to 500 ohms (250 to 500 ohms with a PC-Based configurator or a HART Communicator connected to the transmitter).

Sensor Cable Length

The length of the cable between the sensor and the transmitter can be 30 m (100 ft) maximum.

Write Protection Jumper

Your transmitter has write protection capability which meets the security requirements for use in safety shutdown systems. This means that the local display and remote electronics can be prevented from writing to the electronics. Write protection is set by moving a jumper that is located on the printed wiring board behind the front panel. To activate write protection, open the front panel and place the jumper in the 'protect' position. See Figure 7. In the 'Not Protected' position, writing to certain functions can be limited by password protection.

5. Operation Via Local Display

Controls and Indicators

Operator controls and indicators are located on the front panel. Figure 9 shows the panel arrangement. Table 3 identifies the function of each element.

Figure 9. Indicators and Controls
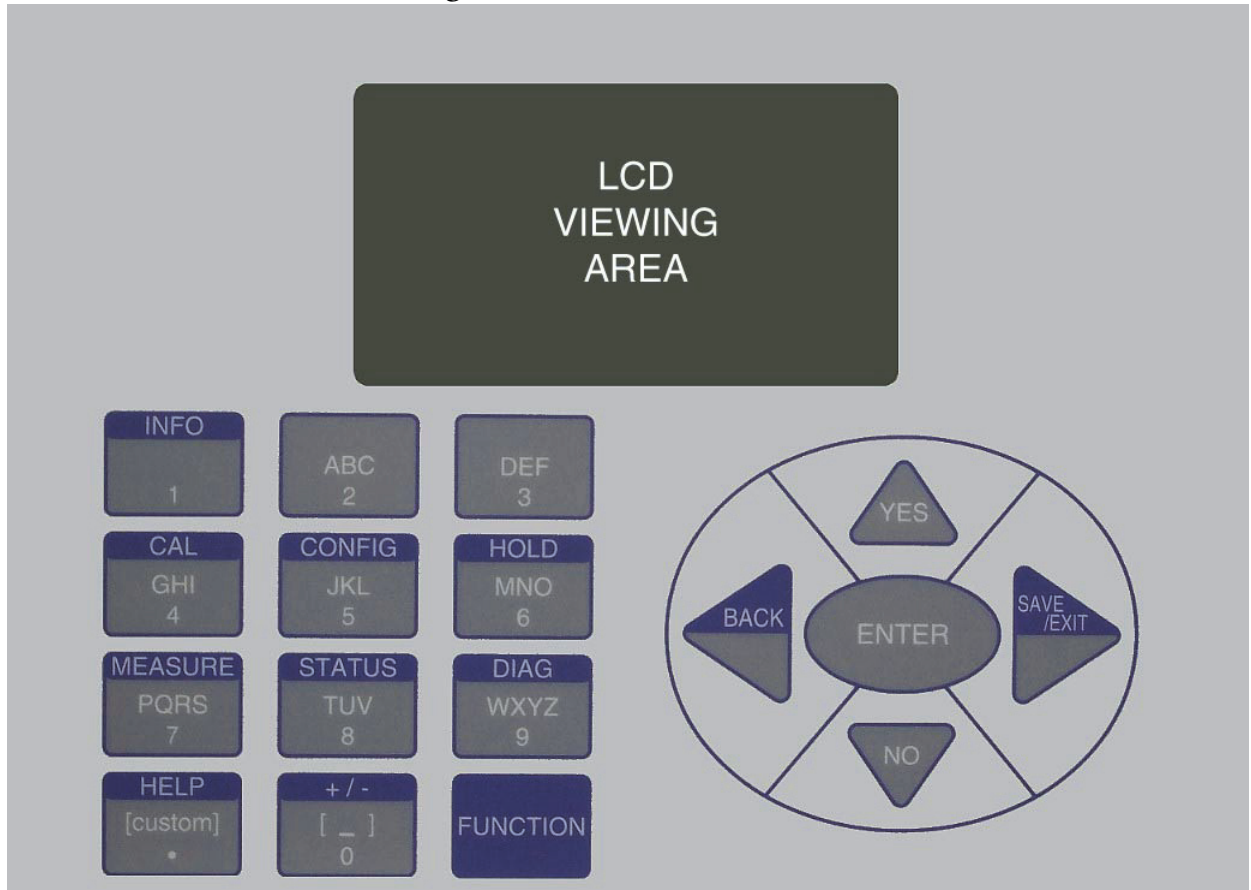
Controls

Table 3. Indicators and Controls

Control/Indicator	Function
FUNCTION Key	Gives you access to the blue function keys.
INFO Key	Used with the Function key, describes the present parameter.
CALibration Key	Used with the Function key, places the transmitter in Calibration mode. This enables you to calibrate the transmitter to the values entered.
CONFIGuration Key	Used with the Function key, places the transmitter in Configuration mode. This enables you to configure the value of each parameter required for your application.
HOLD Key	Used with the Function key, places the transmitter in Hold mode. This enables you to hold the output at a determined value while configuring or calibrating the transmitter or performing sensor maintenance.
MEASUREment Key	Used with the Function key, places the transmitter in Measurement (normal operation) mode.
STATUS Key	Used with the Function key, places the transmitter in Status mode. This enables you to view the measurement and system parameters and thus assess the performance of the loop.
DIAGnostics Key	Used with the Function key, places the transmitter in Diagnostic mode. This enables you to further identify specific errors and possible solutions to an error flagged by the icon in Measurement mode. It is also a means to access the history log.
HELP Key	Used with the Function key, describes how to use the keypad to do the present operation and provides details of menu errors.
+/– Key	Used with the Function key, changes a + value to a – value and vice versa.
Alpha/Numeric Keys	Used for parameter entry. See explanation below.
Direction (Arrow) Keys	Moves you through the menu structure to subsequent menus and values. Also used to move the cursor and change character case.
ENTER Key	Enters (saves) the menu item or value selected. This is the only key that actually enacts a change.
BACK Key	Used with the Function key, moves you back one level in the menu structure regardless of menu errors.
SAVE/EXIT Key	Used with the Function key, asks you if you want to save your entries and then moves you to Measure mode.
YES Key	Used to answer Yes to a Yes/No question.
NO Key	Used to answer No to a Yes/No question.
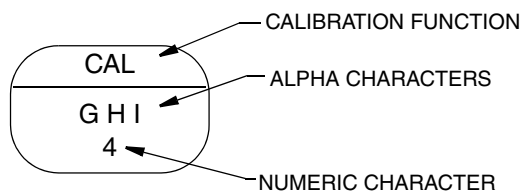
The alpha/numeric keys have several functions as follows:

♦ Access the function shown with a blue background

♦ Enter numeric values

♦ Enter alpha characters (for example, a HART tag, description, or message).

To enter an alpha character, use the key as you would on a cell phone. For example, to enter the word "Acid", use the following sequence"

1. Press the "2" key once to enter the "A" and use the Right arrow key to advance to the next character.

2. Press the "2" key three times to enter the letter "C" and press the Down arrow key to change it to lower case. Use the Right arrow key to advance to the next character.

3. Press the "4" key three times to enter the letter "I" and press the Down arrow key to change it to lower case. Use the Right arrow key to advance to the next character.

4. Press the "3" key once to enter the letter "D" and press the Down arrow key to change it to lower case.

Indicators

The display can be configured to display one, two, or three measurements. However, any measurement can be temporarily scrolled onto the display by using the **Up** and **Down** arrow keys. The display returns to the configured values when you press the **Function** key and then the **Measure** key or when the configured timeout period expires. When the transmitter is in Hold mode, a **Hold** indication appears in the upper right of the title bar. When you press the **Function** key, the function indicator is displayed. If there is a fault, a flashing fault symbol is displayed. If in Measure, Status, or Diagnostic mode, the word **FAULT** also flashes in the lower left of the display.

> ─ **NOTE**
> 1. If **FAULT** is displayed, details of the fault are shown in the Diagnostic mode.
>
> 2. If **CHECK STATUS** is displayed (in the Fault Indicator location), go to Status mode to check for abnormal status.

Figure 10. Sample 3-Line Measurement Display
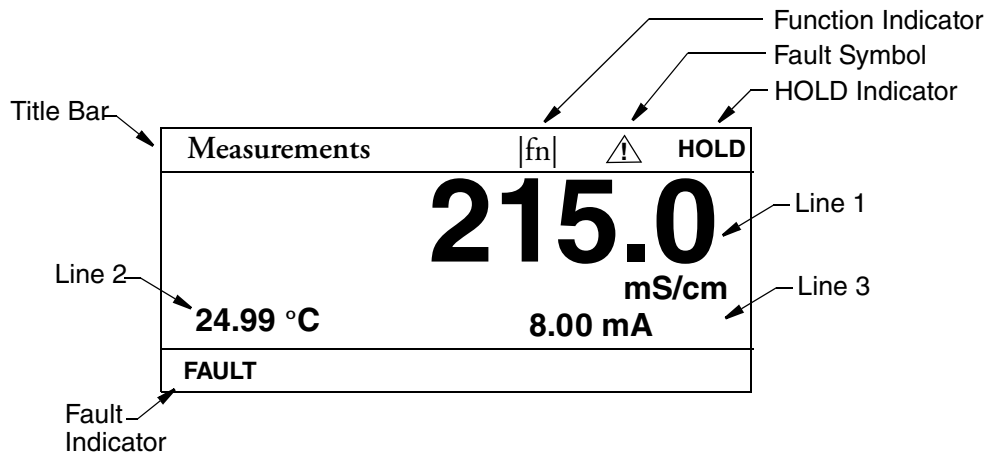
Password Access

Two levels of protection are available. Administrator (**Admin Code**) access permits changing all parameters in Configuration as well as specifying what parameters are accessible by those having User Code access. User (**User Code**) access permits change and viewing access to those areas specified by the administrator. Both are 4-digit passcodes. The passcodes may or may not be the same. They are set as part of configuring the instrument.

Upon entering the Configuration, Calibration, or Hold mode, you may be prompted to enter a passcode. To exit, select another mode.

> **— NOTE**
> Every passcode entry is added to the history log.

If entering Calibration or Configuration mode and you enter the correct passcode, the transmitter responds in one of three ways depending on how **Automatic Hold** is configured. If **Automatic Hold** is configured **Off**, the display cautions you that the transmitter is not in Hold mode. Press **ENTER** to continue. If **Automatic Hold** is configured **Present**, the display cautions that hold is engaged but that outputs are held at the present level. It then unlocks the mode. If **Automatic Hold** is configured **Manual**, the display briefly displays **Hold Engaged** and then unlocks the mode.

The initial factory default value for both Administrator and User passcodes is 0800.

To bypass the passcode, the administrator must configure a passcode of 0000.

Timeout

If there are no key presses within the configured timeout period, the transmitter reverts to Measure mode. You can also return to Measure mode by pressing the **FUNCTION** key and then the **MEASURE** key. If in Configuration or Calibration mode and the automatic hold feature was employed, the output becomes live when the transmitter times out. The timeout feature can be turned off in Configuration mode.

Viewing and Changing Data

In the Configuration, Calibration, Hold, and Diagnostic modes, you need to move through a menu structure of parameters (using the arrow keys and **ENTER** key) to view and/or change the value or status of a particular parameter. Structure diagrams, located in Appendix C, "Configuration Structure Diagrams", will aid you in doing this.

> **— NOTE**
> 1. The Up and Down arrow keys scroll through a menu in either direction.
>
> 2. Using the Function key with the Up and Down arrow keys takes you to the top and bottom of a menu respectively.
>
> 3. If a menu selection is invalid, you will see a selection in inverted text (white letters on black background). This choice is not selectable. To see why, press the HELP key. The help text disappears after you make your choice. To keep the selection, use the BACK key.

The following example will show you how to use the keys in moving through the structure. The example used is that of configuring temperature features. For the example, assume Fahrenheit temperature units, an automatic temperature mode, and a fail temp value of 77°F. Refer to Figure 11.

1. To enter the Configuration mode, press the **FUNCTION** key and then the **CONFIG** key. Enter the passcode if prompted, and press **ENTER**.

2. Press the Down arrow key five times to move from **Sensor Type** to **Temp Config**. Press **ENTER**.

3. The **Temp Config** screen is displayed. **Temp Units** is highlighted. Press **ENTER**.

4. Use the Up or Down arrow key to move to **°F** and press **ENTER**. This enters your Fahrenheit selection and moves the display back to the **Temp Config** screen.

5. Use the Down arrow key to move to **Temp Mode**. Press **ENTER**.

6. The **Temp Mode** screen is displayed. Use the Up or Down arrow key to move to **Auto** and press **ENTER**. This enters your Auto Mode selection and moves the display back to the **Temp Config** screen.

7. Use the Down arrow key to move to **Fail Temp**. Press **ENTER**.

8. The **Fail Temp** screen is displayed.

9. Press the "7" key twice. Press **ENTER**. This enters your selection of 77 and moves the display back one level.

10. Press the **FUNCTION** and **SAVE/EXIT** keys to save your configuration.

Figure 11. Example of Temp Config Menu Structure Diagram

(a) This field displays 871EC Type, 871FT Type, or FT10 Type, depending on Sensor Type chosen in previous field.
(b) Assume Number of Apps = 1
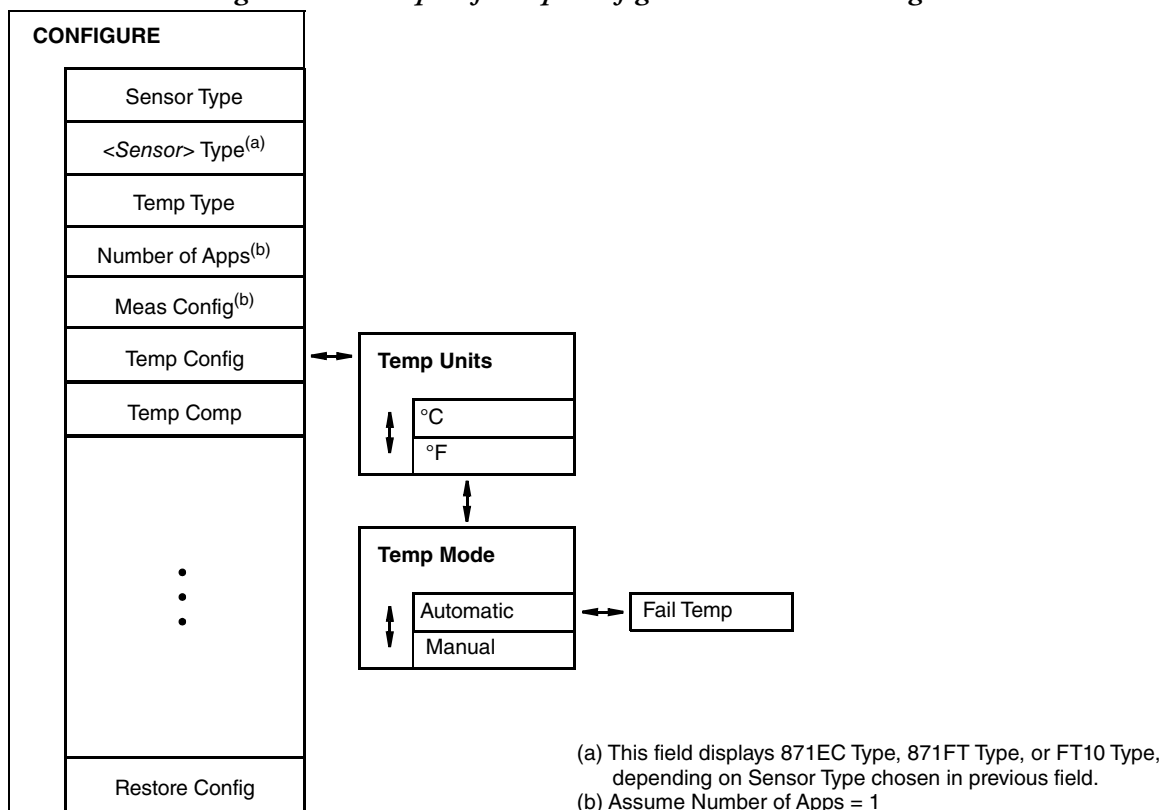
Measure Mode

Measure is the normal operating mode of your analyzer. The analyzer powers up in Measure mode. If another mode is active and you want to go to Measure mode, press the **Mode** key until the **Measure** indicator is illuminated.

Any measured value can be temporarily scrolled onto the display by using the Up and Down arrow keys. See Figure 12. The display returns to the configured values when you press the **FUNCTION** key and then the **MEASURE** key or when the timeout period expires. When the transmitter is in Hold, a hold indication appears in the upper right of the display. If there is a fault, a fault symbol is displayed in the title bar and, if in Measure, Status, or Diagnostic mode, the word **FAULT** flashes in the lower left of the display. See Figure 10.

Figure 12. Measure Mode Structure Diagram
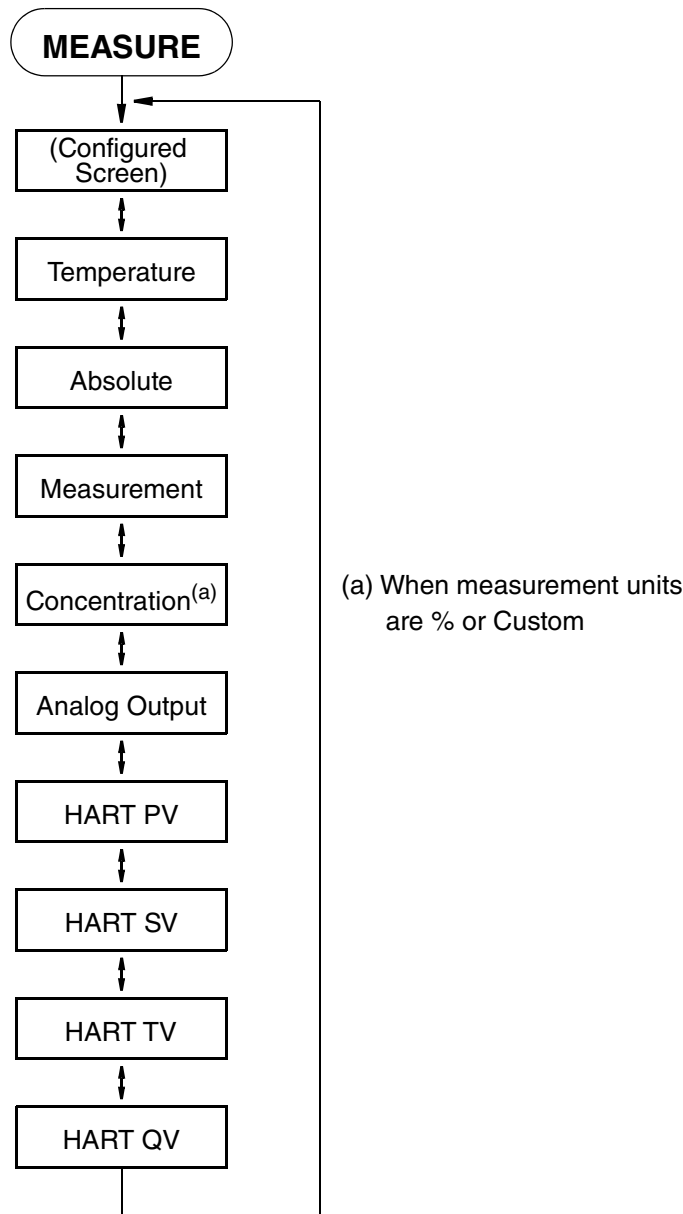
Status Mode

Refer to Figure 13. The Status mode enables you to view the measurement and system parameters and thus assess the performance of the loop. You cannot edit them in this mode. All measurements and outputs continue while you are in the Status mode.

To enter the Status mode, press the **FUNCTION** key and then the **STATUS** key. Move through the menu by using the Up and Down arrow keys. See Figure 13. The Status menu contains the following parameters:

Table 4. Status Parameters

Parameter	Description	Units	Notes
ATC Resistance	Temperature Sensor Resistance	Ohms or kOhms	
ATC Status	Temperature Sensor Status		
Temperature	Process Temperature	°C or °F	
Temp Status	Process Temperature Status		
Cell Resistance	Raw Cell Resistance	Ohms or kOhms	
Cell Status	Raw Cell Status		
Absolute	Uncompensated Measurement	User configurable	
Absolute Status	Uncompensated Measurement Status		
Measurement	Compensated Measurement	User configurable	
Meas Status	Compensated Measurement Status		
Calibrated By	Name of the operator who performed the most recent calibration		
Calibration Date	Date of last calibration (dd mm yyyy)		
Cell Factor	Geometric Cell Factor from last solution calibration; or, if cell type is "Other," the Electronic Cell Factor		
Calibration Points	Cell Resistance and Absolute Measurement at Calibration Point		
Analog Output	Analog Output	mA	
Analog Output Status	Status of analog output	- - -	See Table 5
HART PV	PV measurement		
PV Status	Status of PV	- - -	See Table 5
HART SV	SV measurement		
SV Status	Status of SV	- - -	See Table 5
HART TV	TV measurement		
TV Status	Status of TV	- - -	See Table 5
HART QV	QV measurement		
QV Status	Status of QV	- - -	See Table 5
Model Code	Model code	- - -	
Sales Order	Sales order number	- - -	
Xmtr Serial Number	Transmitter serial number	- - -	
Firmware Revision	Firmware revision level	- - -	
Front End Revision	Front end revision level	- - -	For Global Customer Support use only
Boot Revision	Boot revision level	- - -	For Global Customer Support use only
Transmitter Type	Transmitter type (876EC)	- - -	
In Service	Time in service	Days	

Table 4. Status Parameters (Continued)

Parameter	Description	Units	Notes
HART Tag	HART Tag	- - -	
Tag Name	Tag name	- - -	
Location	Location of measurement	- - -	
Device Name	Device name	- - -	
HART Descriptor	HART Descriptor	- - -	
HART Message	HART Message	- - -	

Figure 13. Status Mode Menu Structure Diagram
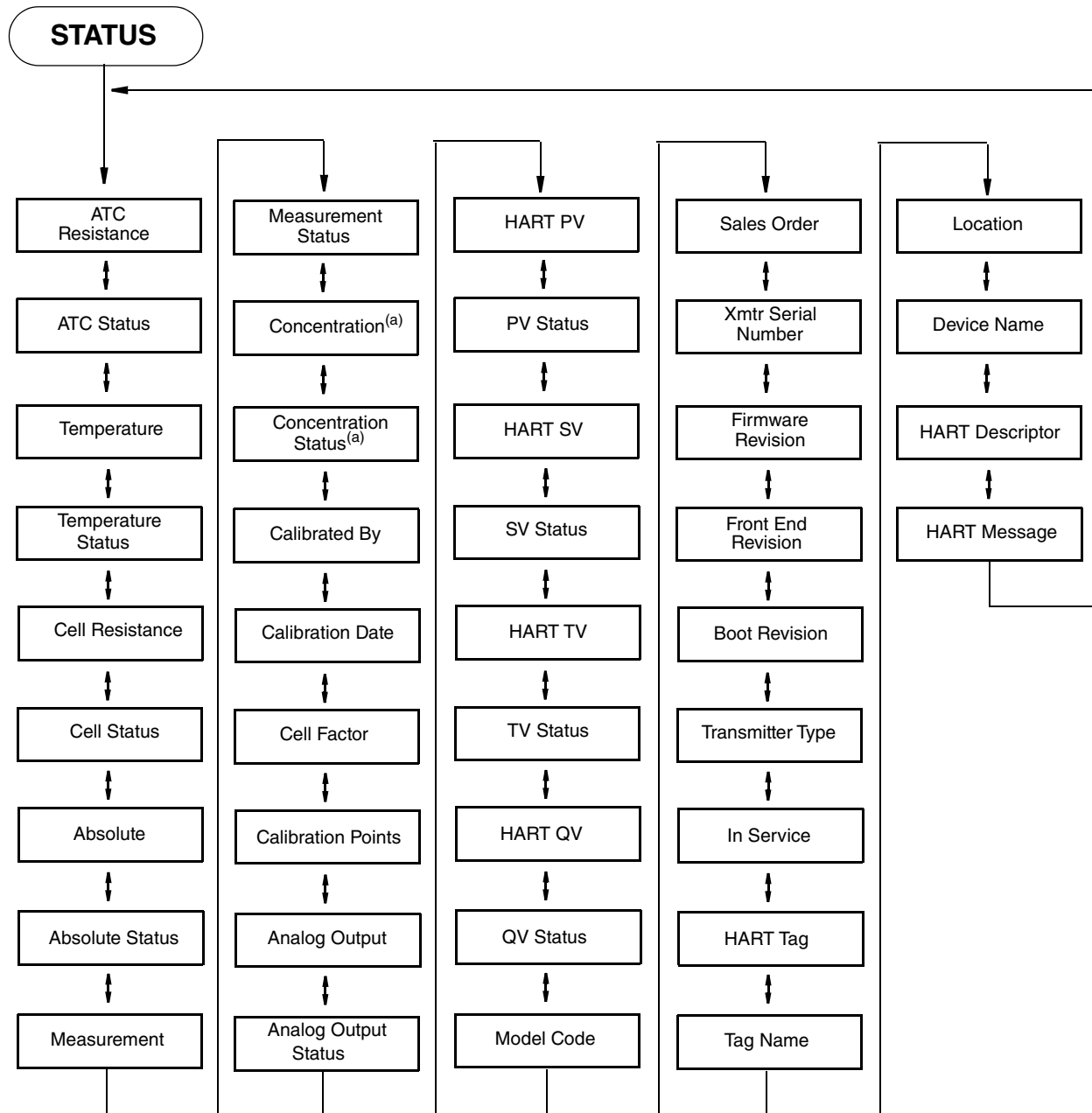
(a) This field displays when Meas Units are % or Custom

Table 5. Status Messages

Displayed Message	Meaning	Information on That Error (a)
Meas OK	Measurement OK	OK. All inputs and calculations for the measurement are OK.
1 InputFixed	Input is fixed	OK. Calculation based on an input is fixed at its manually set value.
Overridden	Measurement is overridden	Measurement has been put into hold mode.
Default	Measurement is fixed	OK. Measurement is fixed at the manually set value.
LimitSoftLow	The measurement is approaching the lower limit	Warning. The measurement is approaching the lower limit.
LimitSoftHi	The measurement is approaching the upper limit	Warning. The measurement is approaching the upper limit.
InputWarning	Input to measurement has a warning	Warning. Measurement input has a warning status.
LimitHardLow	Measurement below low limit	Bad. The measurement has dropped below hard lower limit.
LimitHardHi	Measurement above upper limit	Bad. The measurement has risen above hard upper limit.
1 Input Bad	Input to measurement is bad	Bad. An input to the measurement has a bad status.
MeasStarting	Inputs to measurement are not ready	Bad. A to D converter has not yet measured everything for this individual measurement.
InputStarting	Inputs to measurement are not ready	Bad. A to D converter has not yet measured everything for this individual measurement.

a. Displayed when the Function and Info keys are pressed for that fault.

Hold Mode

Refer to Figure 14.

> **— NOTE —**
> Hold mode may be protected. See "Password Access" on page 27.

The Hold mode enables you to manually hold the output at a determined value, thus allowing you to configure or calibrate the transmitter or perform sensor maintenance without disturbing the control system. Outputs are driven to a preconfigured state or held at their current (present) values. During calibration, the transmitter continues performing live measurements.

> **⚠ WARNING**
> When entering hold, you may want to take your loop out of auto control.

To enter the Hold mode, press the **FUNCTION** key and then the **HOLD** key. In the Hold mode menu, select **On Present** to hold all values and states at their current level or **On Manual** to set all values and states at desired levels or **Off** to release a hold.

If you select **On Present** and press the **ENTER** key, the display briefly reads **Hold Engaged** and proceeds to Measure mode and the outputs are held.

If you select **On Manual** and press the **ENTER** key, the display proceeds to **AO Hold**, the first of a series of parameters to set values and states to desired levels during hold.

> **NOTE**
> Additionally, in Configuration mode, you can use the **Automatic Hold** parameter to automatically activate the Hold feature each time you enter Calibration or Configuration mode. In this Configuration mode parameter, you can select **Off**, **On Present**, or **On Manual**. However, if you select **On Manual**, you must go to Hold mode to set the values.

To set the output for the analog output, enter a value from 3.6 to 22 mA.

You can fix the value for PV, SV, TV, and QV individually. When you have finished making the manual selections, the display briefly reads **Hold Engaged** and returns to the Hold mode menu.

To release Hold, press the **FUNCTION** key and then the **HOLD** key. At the Enter Passcode prompt, enter the correct passcode and press the **ENTER** key. If you enter the incorrect passcode, the display repeats the prompt. If you enter the correct passcode, the display opens the Hold mode. Use the Up or Down arrow key to select **Off** and press **ENTER**. The display briefly reads **Hold Released** and returns to the Hold mode menu.

Figure 14. Hold Mode Menu Structure Diagram
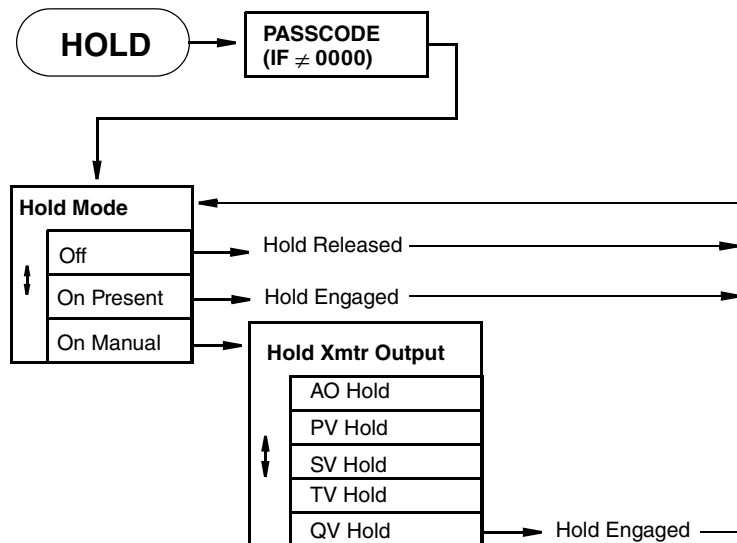
Calibration Mode

Calibration mode allows you to perform three types of calibration procedures: mA Cal, Measurement calibration, and Temperature calibration. See Figure 15.

> **NOTE**
> If using the **Automatic Hold** feature, the outputs are held at the present level or a predetermined level. Returning to Measure mode releases the hold. See "Auto Hold" on page 65 for additional information.

Figure 15. Calibration Menu Structure
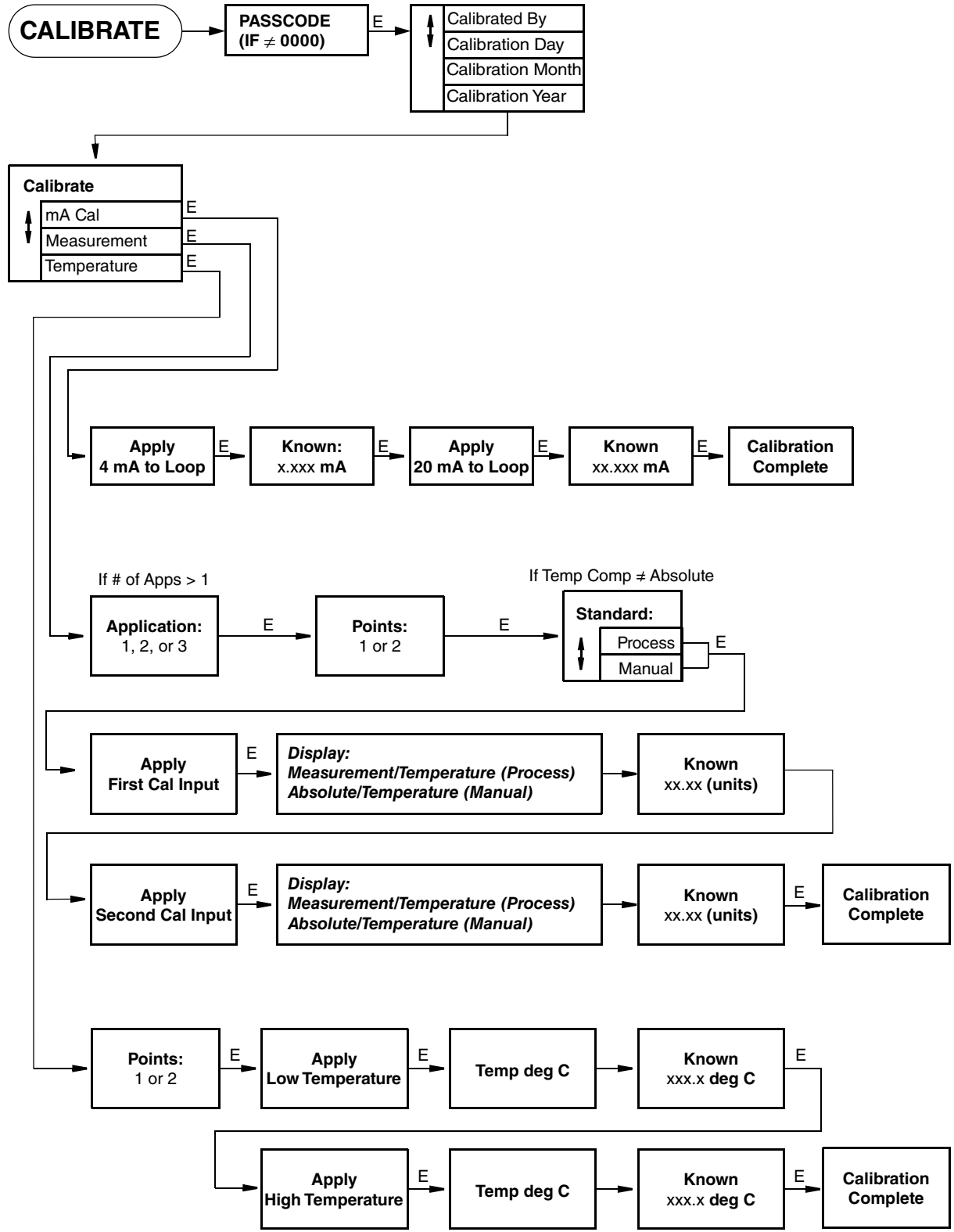
Entering the Calibration Mode

To enter the Calibration mode:

1. Press the **FUNCTION** key and then the **CAL** key.

2. Enter the passcode when prompted, and press **ENTER**.

3. If desired, enter information in the **Calibrated By**, **Calibration Day**, **Calibration Month**, and **Calibration Year** fields. Recording this information is not mandatory, but doing so will allow you to keep track of when the instrument was last calibrated and who performed the calibration.

4. Select **Calibrate** and press **ENTER.**

   The three available calibration selections appear: **mA Cal**, **Measurement**, and **Temperature**:

   ♦ To perform an mA Cal, proceed to the following section.

   ♦ To perform a measurement calibration, proceed to "Measurement Calibration" on page 37.

   ♦ To perform a temperature calibration, proceed to "Temperature Calibration" on page 49.

> **NOTE**
> Calibration mode may be protected. See "Password Access" on page 27.

mA Cal

It is not necessary to perform an mA Calibration (commonly known as mA trim) unless there is a plant requirement to make the 4 and 20 mA output values exactly match the readings on certain plant calibration equipment. If this requirement exists in your plant, and if calibration operations result in small but unacceptable differences between the transmitter mA output and the plant calibration equipment mA readout values, follow the steps in this section to perform an mA Cal.

An mA Cal can be accomplished by:

♦ Inserting a digital current meter into the current loop and reading mA directly

or

♦ Connecting a digital millivolt meter across the mA Cal terminals on the printed wiring board (see Figure 1 or Figure 7) and dividing the millivolt reading by 25 ohms to get mA. This option is recommended because it does not require interruption of the current loop.

> **NOTE**
> mA Calibration may not be an option when the HART Poll Address is not zero, and/or the mA Loop Mode is set to multi-drop. To change these settings, press the **FUNCTION** key and then the **CONFIG** key. Press **ENTER**. Scroll down to **HART Digital** and press **ENTER**.

To perform an mA Cal:

1. Enter the calibration mode:

    a. Press the **FUNCTION** key and then the **CAL** key.

    b. At the prompt, type the passcode and press **ENTER**.

    c. If desired, enter information in the **Calibrated By**, **Calibration Day**, **Calibration Month**, and **Calibration Year** fields. Recording this information is not mandatory, but doing so will allow you to keep track of when the instrument was last calibrated and who performed the calibration.

    d. Select **Calibrate** and press **ENTER**.

2. Select **mA Cal**, and press **ENTER**.

3. Connect a digital current meter in the loop or a digital millivolt meter across the mA Cal terminals on the printed wiring board.

4. At the **Apply 4mA to Loop** prompt, press **ENTER**.

5. At the **Known** prompt, enter the mA value measured with the current meter or the millivolt value measured with the millivolt meter divided by 25, and press **ENTER**.

6. At the **Apply 20mA to Loop** prompt, press **ENTER**.

7. At the **Known** prompt, enter the mA value measured with the current meter or the millivolt value measured with the millivolt meter divided by 25, and press **ENTER**.

8. When calibration is done, the display reads **Calibration Complete**.

9. Press the **FUNCTION** key and **SAVE/EXIT** key to save your calibration.

Measurement Calibration

Measurement calibration offers a variety of options for calibrating the loop (the transmitter, the cabling, and the sensor) in conductivity or concentration units.

The calibration procedure in the 876EC is essentially the same for all measurement calibration options. The sequence of prompts will vary depending on the type of calibration you are performing, for example, if you choose a 2-point calibration or a 1-point calibration.

The procedure is also slightly different if you choose a Process or Manual calibration. When performing a Manual calibration, the transmitter does not apply temperature compensation, even though temperature compensation may be configured and enabled during normal measurement operation. Thus, a Manual calibration assumes that the conductivity calibration values are uncompensated (absolute) values. When performing a Process calibration, the transmitter applies temperature compensation continuously during calibration. Conductivity values used in a Process calibration are therefore being converted to reference temperature (normally 25°C but configurable per the user's setup).

    ♦ If you are performing a **Process** calibration, enter calibration values in the selected conductivity or concentration units *as if at the reference temperature, regardless of actual temperature.*

    ♦ If you are performing a Manual calibration, enter calibration values in the selected **Display Conductivity Units** when prompted. If you selected concentration display units, enter calibration values in the selected conductivity **Base Units**.

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♦ If you are performing a Manual calibration with actual solutions (referred to as the "**Manual**/Solution" option later in this document), enter *absolute* (uncompensated) solution conductivity values that correspond to the *actual calibration temperature*.

♦ If you are performing a Manual calibration with fixed resistances (referred to as the "**Manual**/Bench" option later in this document), simply enter the conductivity calibration value used to calculate resistance.

Before Beginning a Measurement Calibration

Before starting the calibration procedure, determine which calibration types and options are most appropriate for your process, and then make sure you have the required calibration equipment available.

1. Note the sensor type you are calibrating: 871EC, 871FT, or FT10. The calibration method you choose depends on the type of sensor you are calibrating. Refer to Table 6.

2. Choose the equipment with which you will perform the calibration procedure. Available calibration methods and equipment options include:

   a. Loop(s) of wire and a decade resistance box

   b. Calibration plugs

   c. Calibration cable and a decade resistance box

   d. Wet solutions

   e. Open air

   For guidelines and additional information about calibration equipment, refer to Appendix A, "Calibration Guidelines and Examples".

3. Choose a 1-point or 2-point calibration.

   For guidelines and additional information about 1-point and 2-point calibrations, refer to "1-Point and 2-Point Calibrations" on page 86.

4. Choose a **Process** or **Manual** calibration.

   For guidelines and additional information on choosing between a **Process** and **Manual** calibration, refer to "Process and Manual Calibrations" on page 87.

5. Determine the conductivity or concentration values for the low and high calibration point(s).

   For guidelines on determining the conductivity or concentration values for the low and high calibration points, refer to "Determining Conductivity Calibration Values" on page 88

6. If you are performing a Manual calibration, decide whether you will use actual solutions (referred to as the "**Manual**/Solution" option later in this document) or known fixed resistances (referred to as the "**Manual**/Bench" option later in this document) to perform the calibration. For guidelines, refer to "Process and Manual Calibrations" on page 87.

   For guidelines and additional information about **Manual** calibrations, refer to "Process and Manual Calibrations" on page 87.

7. If you are performing a **Manual**/Bench calibration, calculate the resistance(s) that simulate the selected solution conductivity value(s).

   For guidelines and additional information on calculating resistances, refer to "Calculating Resistance Values" on page 95.

Table 6. Recommended Calibration Methods for 871EC, 871FT, and FT10 Sensors

Calibration Method and Equipment	Sensor Type		
	871EC Sensor	871FT Flow-Through Sensor	FT10 Flow-Through Sensor
Open Air **Example 3**: page 100	Simulation of zero conductivity for use as low point in 2-point calibration (a). Must meet requirements in Table 13 on page 85.	Simulation of zero conductivity for use as low point in 2-point calibration (b). Must meet requirements in Table 13 on page 85.	Simulation of zero conductivity for use as low point in 2-point calibration. (b) Must meet requirements in Table 13 on page 85.
User-supplied loop of wire with decade resistance box **Procedure**: page 40 **Example 3**: page 100 **Example 4**: page 102	Most common and convenient method of calibrating an 871EC sensor. Sensor must be removed from the process.	Sensor must be removed from process, so this is not the most convenient method for these sensor types.	Impractical
Calibration plug **Procedure**: page 42 **Example 5**: page 103	Another convenient method of calibrating 871EC providing sensor can be removed from process. Preferred method of calibration, typically providing the greatest accuracy - a pair is recommended.	Most common and convenient method of calibrating an 871FT sensor. Sensor may remain in place. (b)	Most common and convenient method of calibrating an FT10 sensor. (b)
Calibration cable with decade resistance box **Procedure**: page 43 **Example 5**: page 103	Not available for invasive sensors like 871EC.	Another convenient method of calibrating 871FT sensor. Limited at low conductivity end.	Another convenient method of calibrating FT10 sensor. Limited at low conductivity end.
User-supplied calibration solution **Procedure**: page 45 **Example 1**: page 97	"Wet" calibrations are not recommended. Sensor is best removed from process and dipped in vessels of calibrating solution. (c)	Sensor is best removed from process and filled with calibrating solution(s). (c)	Sensor is best removed from process and filled with calibrating solution(s). (c)
Process solution **Procedure**: page 48 **Example 2**: page 99	1-point, in-process calibration based on grab sample analysis, or 1- or 2-point with sensor removed from process in simulated process solutions. (c)	1-point, in-process calibration based on grab sample analysis, or 1- or 2-point with sensor removed from process in simulated process solutions. (c)	1-point, in-process calibration based on grab sample analysis, or 1- or 2-point with sensor removed from process in simulated process solutions. (c)

a. Accomplished by suspension of sensor in air.

b. Accomplished by emptying sensor of fluid.

c. In-process calibrations can be carried out if a suitable system is designed and built by user. Also see Appendix B, "Auto Calibration".

User-Supplied Loop of Wire with Decade Resistance Box

This section provides the general procedure for performing a typical calibration using loops of user-supplied wire and a decade resistance box.

> **— NOTE ————————————————————————**
> Although a loop or loops of wire can be used to calibrate any type of electrodeless sensor, this technique is best suited to invasive sensors such as the 871EC Series, since it is simple to loop the wire through the bore or "donut" in the sensor.

1. Determine the conductivity or concentration values for the low and high calibration point(s).

    For guidelines on determining the conductivity or concentration values for the low and high calibration points, refer to:

Sensor Type	Refer to
871EC	Table 14
871FT	Table 15
FT10	Table 16

    Many users prefer to use open air as the low point (conductivity = zero). This does not yield the most accurate calibration for low conductivity values, but is generally acceptable for wide ranging applications. For specific guidelines about the use of open air calibrations, including the lowest conductivity calibration point to be used as the high calibration value, refer to "Open Air Calibration" on page 85.

2. Calculate the resistance values (Ω) that simulate the selected low and high conductivity values determined in the previous step.

    $$R = \frac{1000 \times Cf \times n^2}{C \text{ (mS/cm)}}$$

    Where:

    ♦ R is the resistance in ohms (Ω)

    ♦ Cf is the sensor's cell factor in cm^{-1} (see Table 17)

    ♦ n is the number of times the wire will be looped through the sensor

    ♦ C is the conductivity value in mS/cm chosen in Step 1

    For guidelines and additional information on calculating resistances, refer to "Calculating Resistance Values" on page 95.

3. Set the decade resistance box to the low calibration point's resistance calculated in Step 2.

4. Wire the transmitter, and connect the decade resistance box.

5. Enter the calibration mode:

    a. Press the **FUNCTION** key and then the **CAL** key.

    b. At the prompt, type the passcode and press **ENTER**.

    c. If desired, enter information in the **Calibrated By**, **Calibration Day**, **Calibration Month**, and **Calibration Year** fields. Recording this information is not mandatory, but doing so will allow you to keep track of when the instrument was last calibrated and who performed the calibration.

    d. Select **Calibrate** and press **ENTER**.

6. Select the **Measurement** calibration type and press **ENTER**.

7. If more than 1 application is configured, a prompt will appear to select the application number to which to apply calibration. Type the application number and press **ENTER**.

8. At the **Points** prompt, enter **1** for a 1-point calibration or **2** for a 2-point calibration and press **ENTER**.

9. Select **Manual** at the **Standard** prompt and press **ENTER**.

— **NOTE** —————————————————————————————————————
The option to choose **Process** or **Manual** does not appear in the menu if **Absolute** was selected in Temp Comp (See "Temp Comp" on page 56).
——

10. At the **Apply First Cal Input** prompt, press **ENTER**.

11. At the **Known** prompt, type the first point's conductivity value chosen in Step 1 and press **ENTER**.

    While the reading is stabilizing, absolute conductivity and temperature values are displayed.

12. Set the decade resistance box to the resistance value associated with the second (high) calibration point. This value was calculated in Step 2.

13. At the **Apply Second Cal Input** prompt, press **ENTER**.

14. At the **Known** prompt, type the second point's conductivity value chosen in Step 1 and press **ENTER**.

15. If more than 1 application is configured, repeat Steps 7 through 14 for each application.

16. When calibration is done, the display reads **Calibration Complete**. Press **ENTER**.

17. Press the **FUNCTION** key and **SAVE/EXIT** key to save your calibration.

— **NOTE** —————————————————————————————————————
When using temperature compensation, keep in mind that the compensated readings after calibration may not agree with the absolute readings.
——

Calibration Plugs

This section provides the general procedure for performing a typical calibration using two calibration plugs: one configured to the resistance associated with the low calibration point and the other configured to the resistance associated with the high calibration point.

Many users prefer to use open air as the low point (conductivity = zero). This does not yield the most accurate calibration for low conductivity values, but is generally acceptable for wide ranging applications. For specific guidelines about the use of open air calibrations, including the lowest conductivity calibration point to be used as the high calibration value, refer to "Open Air Calibration" on page 85.

─ **NOTE** ─────────────────────────────────

Using Foxboro calibration plugs is an efficient method of calibrating 871FT and FT10 flow-through sensors, since these sensor types are equipped with connection ports. The calibration plugs are configured at the factory according to customer-specified calibration conductivity values, and the plugs are labeled with the sensor type and conductivity calibration values specified. Also note that the sensors must be empty of process fluid prior to performing the calibration procedure.

───

1. Wire the transmitter, and connect the calibration plug associated with the low calibration point (C_L). You can find this value on the Foxboro Calibration Plug.

2. Enter the calibration mode:

    a. Press the **FUNCTION** key and then the **CAL** key.

    b. At the prompt, type the passcode and press **ENTER**.

    c. If desired, enter information in the **Calibrated By**, **Calibration Day**, **Calibration Month**, and **Calibration Year** fields. Recording this information is not mandatory, but doing so will allow you to keep track of when the instrument was last calibrated and who performed the calibration.

    d. Select **Calibrate** and press **ENTER**.

3. Select the **Measurement** calibration type and press **ENTER**.

4. If more than 1 application is configured, a prompt will appear to select the application number to which to apply calibration. Type the application number and press **ENTER**.

5. At the **Points** prompt, enter **1** for a 1-point calibration or **2** for a 2-point calibration and press **ENTER**.

6. Select **Manual** at the **Standard** prompt and press **ENTER**.

─ **NOTE** ─────────────────────────────────

The option to choose **Process** or **Manual** does not appear in the menu if **Absolute** was selected in Temp Comp. (See "Temp Comp" on page 56).

───

7. At the **Apply First Cal Input** prompt, press **ENTER**.

    While the reading is stabilizing, absolute conductivity and temperature values appear on the display.

8. At the **Known** prompt, type the calibration plug's conductivity value (C_L from Step 1) and press **ENTER**.

9. Disconnect the first calibration plug, and connect the calibration plug associated with the high calibration point (C_H). You can find this value on the Foxboro Calibration Plug.

10. At the **Apply Second Cal Input** prompt, press **ENTER**.

    While the reading is stabilizing, absolute conductivity and temperature values appear on the display.

11. At the **Known** prompt, type the calibration plug's conductivity value (C_H from Step 9) and press **ENTER**.

12. If more than 1 application is configured, repeat Steps 4 through 11 for each application.

13. When calibration is done, the display reads **Calibration Complete**. Press **ENTER**.

14. Press the **FUNCTION** key and **SAVE/EXIT** key to save your calibration.

> — **NOTE** ————————————————————————————
>
> When using temperature compensation, keep in mind that the compensated readings after calibration may not agree with the absolute readings.

Calibration Cable with Decade Resistance Box

This section provides the general procedure for performing a typical calibration using a calibration cable and a decade resistance box.

> — **NOTE** ————————————————————————————
>
> Using Foxboro calibration cables and a decade resistance box is an efficient method of calibrating 871FT and FT10 flow-through sensors, since these sensor types are equipped with connection ports that allow direct connection of a resistance using a Foxboro Calibration Cable (PN BS807BD). However, calibration cables should not be used with resistances above 1.5 kΩ. Also note that the sensors must be empty of process fluid prior to performing the calibration procedure.

1. Determine the conductivity or concentration values for the low and high calibration point(s).

    For guidelines on determining the conductivity or concentration values for the low and high calibration points, refer to:

Sensor Type	Refer to
871FT	Table 15
FT10	Table 16

    Many users prefer to use open air as the low point (conductivity = zero). This does not yield the most accurate calibration for low conductivity values, but is generally acceptable for wide ranging applications. Also note that you should disconnect the calibration cable when calibrating open air. For specific guidelines about the use of open air calibrations, including the lowest conductivity calibration point to be used as the high calibration value, refer to "Open Air Calibration" on page 85.

2. Calculate the resistance values (Ω) that simulate the selected low and high conductivity values determined in the previous step.

$$R = \frac{1000 \times Cf \times n^2}{C \text{ (mS/cm)}}$$

Where:

♦ *R* is the resistance in ohms (Ω)

♦ *Cf* is the sensor's cell factor in cm^{-1} (see Table 17)

♦ *n* is the number of times the wire will be looped through the sensor

♦ *C* is the conductivity value (mS/cm) chosen in Step 1

For guidelines and additional information on calculating resistances, refer to "Calculating Resistance Values" on page 95.

3. Set the decade resistance box to the low calibration point's resistance calculated in Step 2.

4. Wire the transmitter, and connect the calibration cable and the decade resistance box.

5. Enter the calibration mode:

   a. Press the **FUNCTION** key and then the **CAL** key.

   b. At the prompt, type the passcode and press **ENTER**.

   c. If desired, enter information in the **Calibrated By**, **Calibration Day**, **Calibration Month**, and **Calibration Year** fields. Recording this information is not mandatory, but doing so will allow you to keep track of when the instrument was last calibrated and who performed the calibration.

   d. Select **Calibrate** and press **ENTER**.

6. Select the **Measurement** calibration type and press **ENTER**.

7. If more than 1 application is configured, a prompt will appear to select the application number to which to apply calibration. Type the application number and press **ENTER**.

8. At the **Points** prompt, enter **1** for a 1-point calibration or **2** for a 2-point calibration and press **ENTER**.

9. Select **Manual** at the **Standard** prompt and press **ENTER**.

─ **NOTE** ───
The option to choose **Process** or **Manual** does not appear in the menu if **Absolute** was selected in Temp Comp. (See "Temp Comp" on page 56).
──

10. At the **Apply First Cal Input** prompt, press **ENTER**.

11. At the **Known** prompt, type the first point's conductivity value chosen in Step 1 and press **ENTER**.

    While the reading is stabilizing, absolute conductivity and temperature values appear on the display.

12. Set the decade resistance box to the resistance value associated with the second (high) calibration point. This value was calculated in Step 2.

13. At the **Apply Second Cal Input** prompt, press **ENTER**.

14. At the **Known** prompt, type the second point's conductivity value chosen in Step 1 and press **ENTER**.

15. If more than 1 application is configured, repeat Steps 7 through 14 for each application.

16. When calibration is done, the display reads **Calibration Complete**. Press **ENTER**.

17. Press the **FUNCTION** key and **SAVE/EXIT** key to save your calibration.

─── **NOTE** ───

When using temperature compensation, keep in mind that the compensated readings after calibration may not agree with the absolute readings.

───

User-Supplied Calibration Solutions

The **Manual**/Bench calibration using fixed resistances (wire loops, decade resistance boxes, calibration cables, or calibration plugs) is the most convenient and foolproof calibration technique. However, there may be circumstances under which you need to use actual solutions to perform the calibration procedure.

1. Process calibrations require the use of actual solutions. You can perform the Process calibration outside the process with solutions that match or simulate the chemical composition of the process solution, or you can perform a Process calibration while the sensor remains immersed in the process solution (as described in "Using Process Solutions" on page 48.

2. Manual calibrations can be carried out with actual user-supplied solutions, but the following must be taken into account:

    ♦ This method is obviously simplest with invasive cells that can be uninstalled from the process and dipped into vessels of user-supplied solution.

    ♦ Flow-through cells can be placed on a bench and filled and flushed with solutions, but this is quite time-consuming and technique-intensive. Systems to fill flow-through cells with calibrating solutions in situ are possible, as described in Appendix B, "Auto Calibration", but in general this method is best suited to invasive cells while uninstalled from the process.

    ♦ An additional requirement for Manual/Solution calibration is that the conductivity values of the user-supplied solutions must be known at all temperatures within the expected temperature range over which calibration will be carried out.

This section provides the general procedure for performing a typical calibration using actual solutions separate from the process.

1. Determine the conductivity or concentration values for the low and high calibration point(s).

   For guidelines on determining the conductivity or concentration values for the low and high calibration points, refer to:

Sensor Type	Refer to
871EC	Table 14
871FT	Table 15
FT10	Table 16

> — **NOTE** —
> When using solutions, make sure you have the solution's conductivity tables covering all relevant temperatures readily available.

   Many users prefer to use open air as the low point (conductivity = zero). This does not yield the most accurate calibration for low conductivity values, but is generally acceptable for wide ranging applications. For specific guidelines about the use of open air calibrations, including the lowest conductivity calibration point to be used as the high calibration value, refer to "Open Air Calibration" on page 85.

2. Fill calibration vessels with the two standard solutions, and allow the solutions to equilibrate to a stable temperature.

> — **NOTE** —
> For 871EC invasive sensors, the calibration vessel should be large enough for the sensor to be suspended at least 1.5 in (4 cm) from any surface including that of the liquid.
> For flow-through sensors, Process or Manual/Solution calibrations are possible, but inconvenient. Whereas invasive sensors can easily be dipped into vessels of standard solution, flow-through sensors such as the 871FT and FT10 Series require provisions to enable filling, emptying, and flushing. Therefore, **Manual**/Bench calibration is recommended for flow-through sensors.

3. Remove the sensor from the process, rinse it, dry it, and place it in the solution with the lower value.

4. Enter the calibration mode:

   a. Press the **FUNCTION** key and then the **CAL** key.

   b. At the prompt, type the passcode and press **ENTER**.

   c. If desired, enter information in the **Calibrated By**, **Calibration Day**, **Calibration Month**, and **Calibration Year** fields. Recording this information is not mandatory, but doing so will allow you to keep track of when the instrument was last calibrated and who performed the calibration.

   d. Select **Calibrate** and press **ENTER**.

5. Select the **Measurement** calibration type and press **ENTER**.

6. If more than 1 application is configured, a prompt will appear to select the application number to which to apply calibration. Type the application number and press **ENTER**.

7. At the **Points** prompt, enter **1** for a 1-point calibration or **2** for a 2-point calibration and press **ENTER**.

8. Select **Manual** at the **Standard** prompt, and press **ENTER**.

─ **NOTE** ──

The option to choose **Process** or **Manual** does not appear in the menu if **Absolute** was selected in Temp Comp (See "Temp Comp" on page 56).

──

9. At the **Apply First Cal Input** prompt, place the sensor in the solution with the lower concentration value and press **ENTER**.

10. For a Manual calibration, the pre-calibration absolute conductivity value and current temperature values appear while the reading is stabilizing. *Record the solution temperature and look up the absolute conductivity value for the first solution at that temperature.*

11. At the **Known** prompt, type the known absolute conductivity value at the actual temperature and press **ENTER**.

12. Rinse and dry the sensor, and place the sensor in the solution with the higher concentration value.

13. At the **Apply Second Cal Input** prompt, press **ENTER**.

14. For a Manual calibration, the pre-calibration absolute conductivity value and current temperature values appear while the reading is stabilizing. *Record the solution temperature and look up the absolute conductivity value for the second solution at that temperature.*

15. At the **Known** prompt, type the known absolute conductivity value at the actual temperature and press **ENTER**.

16. If more than 1 application is configured, repeat Steps 6 through 15 for each application.

17. When calibration is done, the display reads **Calibration Complete**. Press **ENTER**.

18. Press the **FUNCTION** key and **SAVE/EXIT** key to save your calibration.

─ **NOTE** ──
When using temperature compensation, keep in mind that the compensated readings after calibration may not agree with the absolute readings.

──

Using Process Solutions

The **Manual**/Bench calibration using fixed resistances (wire loops, decade resistance boxes, calibration cables, or calibration plugs) is the most convenient and foolproof calibration technique. However, there may be circumstances under which you need to perform a calibration using the current process solution while the sensor remains installed in the process. In this case, you can obtain the calibration value(s) by analyzing a grab sample or other process data.

This section provides the general procedure for performing a typical calibration using the process solution. This procedure applies to both Process and Manual calibrations.

1. Determine the conductivity or concentration values for the low and high calibration point(s).

   For guidelines on determining the conductivity or concentration values for the low and high calibration points, refer to:

Sensor Type	Refer to
871EC	Table 14
871FT	Table 15
FT10	Table 16

   — **NOTE** —————————————————————————————————
   When using solutions, make sure you have the process solution's conductivity tables covering all relevant temperatures readily available.
   ——

2. Enter the calibration mode:

   a. Press the **FUNCTION** key and then the **CAL** key.

   b. At the prompt, type the passcode and press **ENTER**.

   c. If desired, enter information in the **Calibrated By**, **Calibration Day**, **Calibration Month**, and **Calibration Year** fields. Recording this information is not mandatory, but doing so will allow you to keep track of when the instrument was last calibrated and who performed the calibration.

   d. Select **Calibrate** and press **ENTER**.

3. Select the **Measurement** calibration type and press **ENTER**.

4. If more than 1 application is configured, a prompt will appear to select the application number to which to apply calibration. Type the application number and press **ENTER**.

5. At the **Points** prompt, enter **1** for a 1-point calibration and press **ENTER**.

6. Select **Process** at the **Standard** prompt and press **ENTER**.

   — **NOTE** —————————————————————————————————
   The option to choose **Process** or **Manual** does not appear in the menu if **Absolute** was selected in Temp Comp (See "Temp Comp" on page 56).
   ——

7. At the **Apply First Cal Input** prompt, press **ENTER**.

   The pre-calibration measurement value and current temperature values appear while the reading is stabilizing.

8. At the **Known** prompt, enter the known concentration of the process solution and press **ENTER**.

9. If more than 1 application is configured, repeat Steps 6 through 8 for each application.

10. When calibration is done, the display reads **Calibration Complete**. Press **ENTER**.

11. Press the **FUNCTION** key and **SAVE/EXIT** key to save your calibration.

Temperature Calibration

1- or 2-point user calibrations can be applied to the temperature measurement. A 1-point calibration applies an offset adjustment, that is, a fixed temperature adjustment across the entire range. A 2-point calibration applies a linearly varying adjustment across the span between the two chosen temperature points. Any type of temperature calibration completely supersedes previous temperature calibrations. Changing Cell Type restores the factory default temperature calibration.

To perform a Temperature calibration:

1. Enter the calibration mode:

    a. Press the **FUNCTION** key and then the **CAL** key.

    b. At the prompt, type the passcode and press **ENTER**.

    c. If desired, enter information in the **Calibrated By**, **Calibration Day**, **Calibration Month**, and **Calibration Year** fields. Recording this information is not mandatory, but doing so will allow you to keep track of when the instrument was last calibrated and who performed the calibration.

    d. Select **Calibrate** and press **ENTER**.

2. Select **Temperature** and press **ENTER**.

3. At the **Points** prompt, enter **1** for a 1-point calibration or **2** for a 2-point calibration and press **ENTER**.

4. At the **Apply Low Temperature** prompt, place the sensor in solution at the low temperature and press **ENTER**.

    Temperature is temporarily displayed while the process is stabilizing.

5. At the **Known** prompt, enter the known low temperature and press **ENTER**.

6. At the **Apply High Temperature** prompt, place the sensor in solution at the high temperature and press **ENTER**.

    Temperature is temporarily displayed while the process is stabilizing.

7. At the **Known** prompt, enter the known high temperature and press **ENTER**.

8. When calibration is done, the display reads **Calibration Complete**.

9. Press the **Function** key and **Save and Exit** key to save your calibration.

Configuration Mode

> **— NOTE ——————————————————————————————**
>
> 1. Configuration mode may be protected. See "Password Access" on page 27.
>
> 2. If using the **Automatic Hold** feature, the outputs are held at the present level or a predetermined level. Returning to Measure mode releases the hold.

Configuration is the process of establishing functional capability in the transmitter firmware for your application. This section helps you to systematically determine and configure the value or status of each parameter required for your application. It is recommended that you make configuration changes from the beginning of the menu structure forward. This is because menus are forward referencing meaning that if you start at the beginning and work to the end, you achieve a valid configuration. Also, the transmitter validates the configuration when attempting to exit configuration and directs you to any invalid parameters.

To enter the Configuration mode, press the **FUNCTION** key and then the **CONFIG** key. After gaining access to Configuration, the first category in the top level configuration structure, **Cell Config**, is displayed. To view or change another configuration category, press the Up or Down arrow key. When you have located the desired category, press the **ENTER** key. Each category of parameters is shown in subsequent structure diagrams.

> **⚠ CAUTION** ——————————————————————————————
>
> If there are no key presses within the configured Timeout period, the transmitter reverts to Measure mode and all changes are lost.

Sensor Configuration

Refer to Figure 30.

This section of the structure asks you to specify the sensor type, and the temperature features that are used for all three applications.

To configure the sensor type and characteristics:

1. Specify the **Sensor Type** as 871EC, 871FT English, 871FT Metric, EP307, FT10, or Other.

2. If you are configuring an 871EC, 871FT, or FT10 sensor type, specify the **871EC Type**, **871FT Type**, or **FT10 Type** in the associated field. If you selected EP307 or Other as the Sensor Type, continue to the next step.

3. Specify the temperature type as **2-Wire Pt 100**, **2-Wire Pt 1000**, **3-Wire Pt 100**, **3-Wire Pt 1000, Mil RTD, or 100k Thermistor**.

> **— NOTE ——————————————————————————————**
>
> Whenever a Foxboro cell type is selected, a proprietary mathematical algorithm is applied to accelerate the cell's response to changes in the process temperature. This reduces errors that may appear in the compensated measurements when the process temperature changes rapidly. If a Foxboro cell is not in use, for example while verifying transmitter response to resistor inputs, select cell type, **Other**.

Figure 16. FT10 Non-Invasive, Nonmetallic Flow-Through Sensor
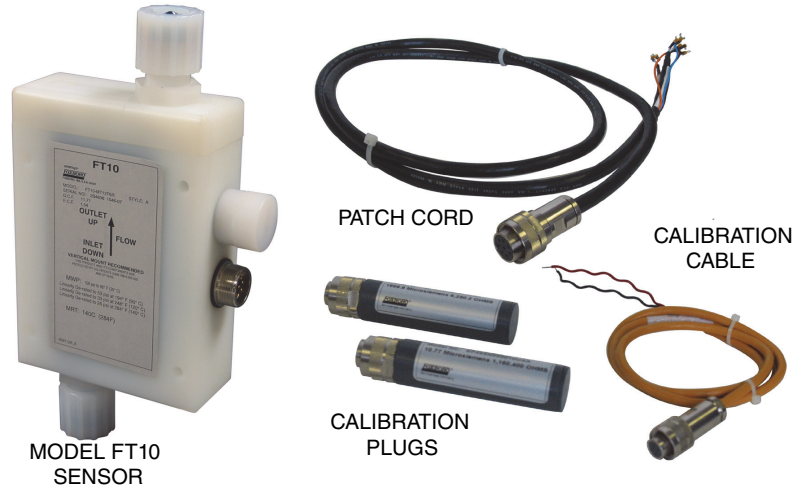
Figure 17. 871FT Industrial and Sanitary Flow-Through Sensors and 871EC Series Sensors
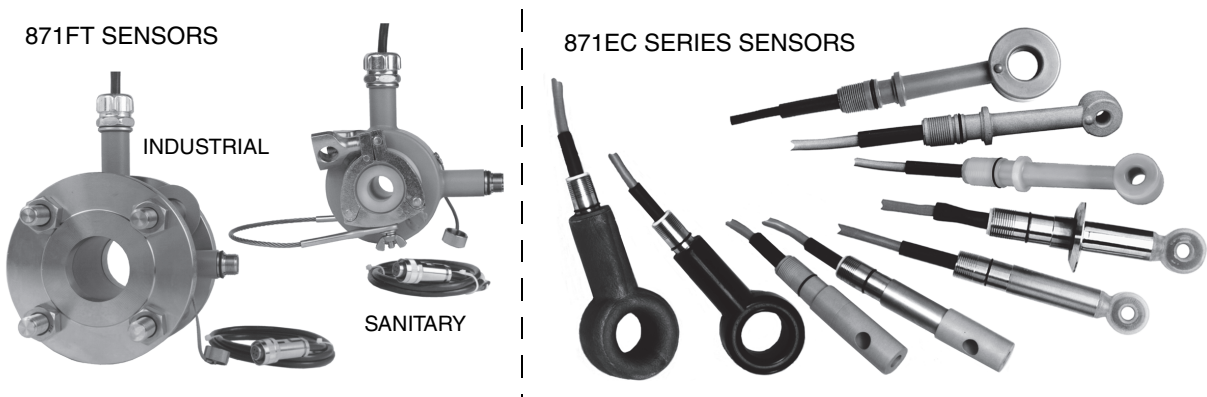
Table 7. 871EC and 871FT Sensor Types

Sensor Type	Model	Temperature Sensor
871EC	SP, RE, LB, NL, TF, EV, PT	Thermistor, 100 k ohm
871EC	HP, BW, UT, PP	RTD, 100 ohm Platinum
EP307	Temp Element Code 1	RTD, 100 ohm Platinum
EP307	Temp Element Code 3	RTD, 1000 ohm Platinum
EP307	Temp Element Code 4	Thermistor, 100 k ohm
871FT	RTD Code T	RTD, 100 ohm Platinum
871FT	RTD Code R	RTD, 1000 ohm Platinum
FT10	RTD Code T	RTD, 100 ohm Platinum
FT10	RTD Code R	RTD, 1000 ohm Platinum

Number of Apps

Refer to Figure 32.

This section of the structure asks you to specify the number of applications you wish to preconfigure. It can be **1**, **2**, or **3**. For more information on this subject, see the following section and "Run Apps" on page 63. In the following subsections, "A#" indicates the application number 1, 2, or 3.

A# Configuration

The 876EC Analyzer can be preconfigured for up to three distinct applications. Each application can have its own measurement and temperature configuration, temperature compensation curve, display, and output configuration. Each user configuration may contain up to three applications. Applications can also autoswitch.

A# Name

Enter the name of the application up to a maximum of 12 characters.

Meas Config, A# Meas Config

Refer to Figure 33.

Meas Unit

Specify the measurement units as **µS/cm**, **µS/m**, **mS/cm**, **mS/m**, **S/m**, **%**, **Custom**

If you selected one of these measurement units, you must specify the Display Format and Damping as explained immediately below.

Display Format

Specify the display format (decimal point placement) of the displayed value per Table 14 on page 90, Table 15 on page 91, and Table 16 on page 94.

Damping

Enter the **Damping** response time up to 300 seconds (for 90% recovery from a step change). To increase damping, use a higher response time. Damping applies only to compensated measurement data, not to temperature or absolute data.

Meas Unit = %

When selecting units of % chemical concentration, the base display scale is automatically selected as follows. Base units are also selected, and this base display scale is converted accordingly. This base display scale may be combined with your sensor type to determine the 1% accuracy range from Table 14, Table 15, and Table 16. Various chemicals, reference temperatures, concentration ranges, temperature compensated ranges, and base display scales are shown in Table 8.

Table 8. Absolute Conductivity (mS/cm) for Various Chemical Concentrations

Chemical	Ref. Temp. (°C)	Temperature Compensated Range (mS/cm)	Base Display Scale (mS/cm)	mS/cm at Various Percent Concentrations									
				1%	5%	10%	15%	20%	42%	65%	93.0%	97.5%	99.5%
Sodium Chloride (NaCl)	25	0 to 252	999.9	18.52	78.87	137.1	186.3	225.7					
Potassium Chloride (KCl)	25	0 to 237	999.9	18.78	78.98	155.6	224.7						
Acetic Acid (CH₃COOH)	25	0 to 1.8230	9.999	0.6402	1.367	1.700	1.822						
Phosphoric Acid (H₃PO₄)	25	0 to 210	999.9	6.667	35.00	65.00	92.86	122.9					
Hydrochloric Acid (HCl)	25	0 to 825	999.9	111.1	433.1	697.0	818.8						
	25	0 to 800	999.9	47.31	220.1	425.6	591.5	715.4					
Sulfuric Acid (H₂SO₄)	30	43 to 150	999.9								149.0	113.8	43.10
	50	60 to 234	999.9								234.4	171.1	63.10
Oleum (low)	65	27 to 80	99.99	38.60	67.30	79.00							
Oleum (high)	65	15 to 80	99.99					74.7	15.00				
Nitric Acid (HNO₃)	25	0 to 525	999.9	58.85	265.2	484.5							
Sodium Hydroxide (NaOH)	25	0 to 420	999.9	49.97	218.1	357.3	420.1						
	50	0 to 681	999.9	75.00	321.0	527.0	650.0						
	100	0 to 1300	9999.	98.00	464.8	824.3	1,104.5	1,260.0					
Potassium Hydroxide (KOH)	25	0 to 500	999.9	39.50	192.1	358.5	497.3						
Hydrofluoric Acid (HF)	0	0 to 490	999.9								358.6	150.3	40.73
Hydrofluoric Acid (HF)	20	0 to 1111	999.9	10.55	54.70	116.0	179.8	246.0	575.3	1,038			

Then specify the base units so that the absolute measurement can be displayed in those units. The **Base Unit** selections are **μS/cm**, **mS/cm**, **mS/m**, **S/m**.

Lastly, enter the **Damping** response time (for 90% recovery from a step change). You can enter a time up to 300 seconds. To increase damping, use a higher response time. Damping applies only to compensated measurement data, not to temperature or absolute data.

Meas Unit = Custom

If you selected **Custom** as your measurement unit, you must specify the **Custom Units** and **Custom Scale**. The **Custom Unit** selections are **%** (percent), **ppt** (parts per thousand), **ppm** (parts per million), **ppb** (parts per billion), **g/l** (grams per liter), **oz/gal** (ounces per gallon), **User defined**, and (**none**). The **Custom Scale** selections are **99.99, 99.999, 999.9, 999.99, 9999, 9999.9, 99999, 0.9999, 0.99999, 9.999, 9.9999**.

Further, you must specify the chemical compensation between the conductivity units (**Base Units**) and the **Custom Unit** of your choice. The Base unit selections are **μS/cm**, **μS/m**, **mS/cm**, **mS/m**, **S/m**. The **Base Scale** selections are **0.9999, 9.9999, 9.999, 99.99, 999.9**, and **9999**.

The process specific compensation data must be generated or extracted in advance of entering it into the analyzer. We suggest that the data be plotted graphically as well as tabularly to prepare it for entry into your analyzer. See Figure 18.

Next, you must specify a number of points (**Num of Pts**) to plot the compensation curve. The number of points can be specified from 2 to 21. Lastly, for each of the number of points specified above, specify a base value (**Base Point #**) and the corresponding custom value (**Custom Point #**).

A maximum or minimum difference between successive concentrations is not required. The intervals do not have to be evenly spaced. We suggest 2 or 3 points be used in linear regions and more data points be used in curved regions. See Figure 19.

Figure 18. Reference Conductivity vs. Concentration Data
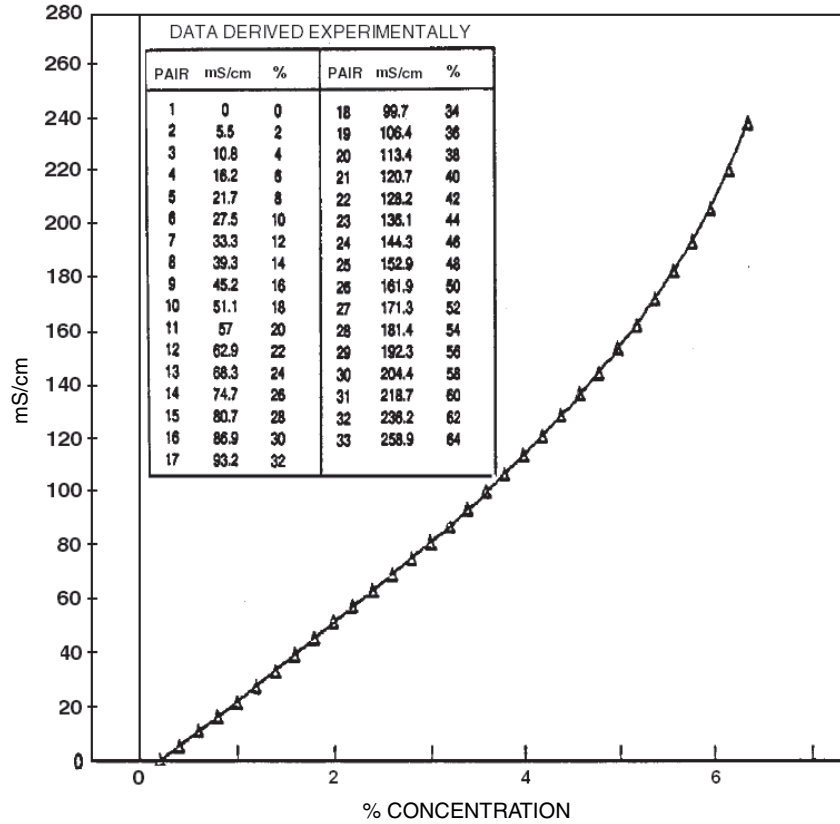
Figure 19. Configured Conductivity vs. Concentration Data
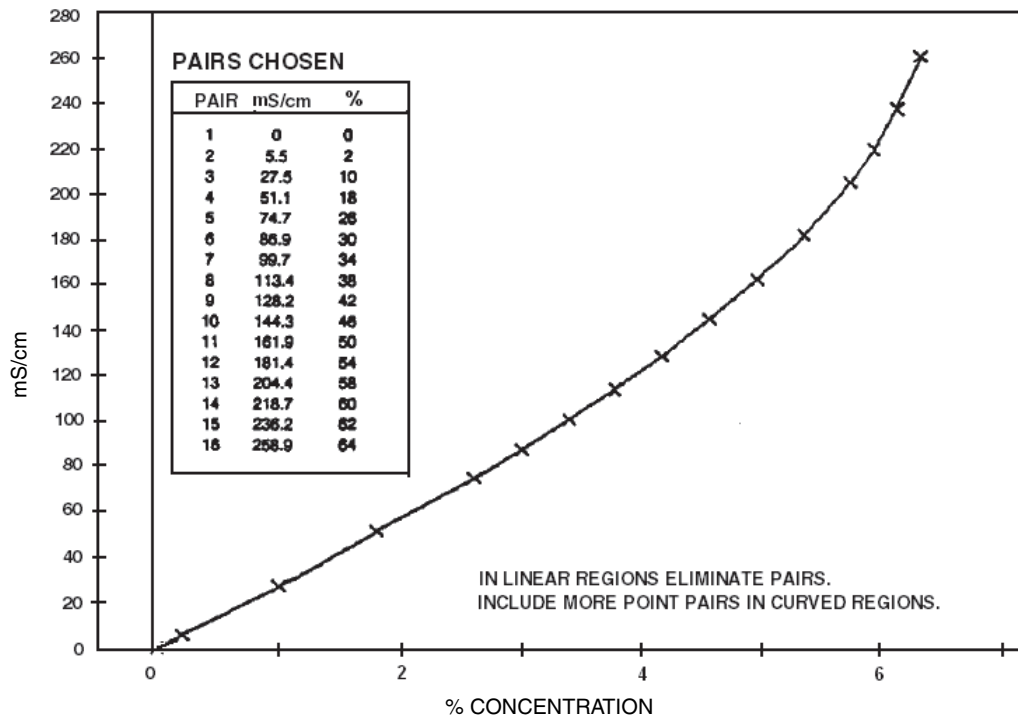
In the example used in Figure 18 and Figure 19, the 33 reference points were reduced to 16 configured points. The configuration procedure would have been as follows:

1. Specify your **Meas Units** as **Custom** and **Custom Units** as **%**.

2. Specify the scale of your custom units. For this example, because they are from 0 to 64% and the degree of accuracy is only required in whole units of percent, specify **Custom Scale** as **9999**.

3. Specify the **Base Units**. For this example, **mS/cm**.

4. Specify the scale of your base values. For this example, because they are from 0 to 258.9, specify **Base Scale** as **999.9**.

5. Specify the number of points (**Num of Pts**) on your curve. For this example, **16**.

6. Specify the sixteen point pairs.

> ── **NOTE** ──────────────────────────────────────
> When entering data, remember to check the ± sign at the left of your display.

Lastly, enter the **Damping** response time (for 90% recovery from a step change). You can enter a time up to 300 seconds. To increase damping, use a higher response time. Damping applies only to compensated measurement data, not to temperature or absolute data.

Temp Config, A# Temp Config

Refer to Figure 34.

Temp Unit

Specify **Temp Unit** as °C or °F. All references to temperature appear in the specified units within the transmitter software.

Temp Mode

Specify the **Temp Mode** as **Automatic** or **Manual**.

In **Automatic** mode, the temperature follows the temperature input RTD and you can set a temperature fail signal value (**Fail Temp**), in case the RTD fails, at the temperature at which you expect the process to be operating.

In **Manual** mode, the temperature can be set at a fixed temperature value (**Manual Temp**) and resistance inputs on the temperature terminal are ignored.

Temp Comp

Refer to Figure 35.

Absolute conductivity measurements are affected by ion concentration and temperature (heat causes ions to have more mobility in solutions, often increasing their conductivity). Temperature compensation adjusts the measurement to a conductivity reading equivalent to that at the reference temperature. You should specify a compensation from those listed in Table 9 that represents your process application most closely. Information on each of the choices follows the table. If your application is not covered in the choices available, either the **Linear** coefficient or

nonlinear **Custom** temperature compensation may be used. You can also select **Absolute** (no temperature compensation).

> ─ **NOTE** ──────────────────────────────────────
> This parameter does not appear if **Meas Units** was configured as percent (%) since the analyzer applies the appropriate compensation automatically.

You are first asked to specify the mode as **Absolute, Dilute NaCl**, **NaCl**, **Sea Water**, **KCl**, **CH$_3$COOH**, **H$_3$PO$_4$**, **HCl**, **H$_2$SO$_4$**, **Oleum**, **HNO$_3$**, **NaOH**, **KOH**, **HF**, **Grn Liquor**, **Blk Liquor**, **Linear**, or **Custom**. The most recently configured entry appears on the display.

Table 9. Chemical Specific Temperature Compensations

Chemical	Reference Temperature	Temperature Range	Absolute Range	Temperature Compensated Range	Concentration Range
Absolute	N/A	Instrument Range	Instrument Range	Instrument Range	N/A
NaCl	25°C	0 to 200°C	0 to 1201 mS/cm	0 to 252 mS/cm	0 to 28%
Sea Water	25°C	0 to 120°C	Instrument Range	Not Specified	N/A
KCl	25°C (a)	0 to 50°C	0 to 356 mS/cm	0 to 237 mS/cm	0 to 16%
CH$_3$COOH	25°C	0 to 110°C	0 to 2.85 mS/cm	0 to 1.83 mS/cm	0 to 15%
H$_3$PO$_4$	25°C	4.4 to 93.3°C	0 to 300 mS/cm	0 to 210 mS/cm	0 to 36%
HCl	25°C	-10 to +122°C	0 to 1860 mS/cm	0 to 825 mS/cm	0 to 15%
H$_2$SO$_4$	25°C (a)	5 to 110°C	0 to 1440 mS/cm	0 to 800 mS/cm	0 to 25%
	30°C	20 to 90°C	34 to 435 mS/cm	43 to 150 mS/cm	99.5 to 93%
	50°C	-10 to +120°C	24 to 613 mS/cm	60 to 234 mS/cm	99.5 to 93%
Oleum	65°C	32 to 120°C	19 to 176 mS/cm	27 to 80 mS/cm	0 to 10%
			10 to 176 mS/cm	15 to 80 mS/cm	42 to 18%
HNO$_3$	25°C	-10 to +120°C	0 to 893 mS/cm	0 to 525 mS/cm	0 to 10%
NaOH	25°C (a)	0 to 120°C	0 to 1176 mS/cm	0 to 420 mS/cm	0 to 15%
	50°C	0 to 100°C	0 to 987 mS/cm	0 to 616 mS/cm	0 to 15%
		50 to 100°C	0 to 1090 mS/cm	0 to 681 mS/cm	0 to 17%
	100°C	75 to 122°C	0 to 1560 mS/cm	0 to 1300 mS/cm	0 to 22%
KOH	25°C	10 to 55°C	0 to 750 mS/cm	0 to 500 mS/cm	0 to 15%
HF	0°C	-10 to +208°C	0 to 922 mS/cm	0 to 485 mS/cm	100 to 90%
	20°C (a)	0 to 50°C	0 to 1350 mS/cm	0 to 1110 mS/cm	0 to 70%
Kraft Green Liquor	85°C	35 to 95°C	Instrument Range	Not Specified	N/A
Kraft Black Liquor	160°C	100 to 175°C	Instrument Range	Not Specified	N/A
Linear	As Entered	Instrument Range	Instrument Range	Not Specified	N/A
Custom	As Entered	As Entered	Instrument Range	Not Specified	As Entered

a. Patented 3D Temperature Compensation

Absolute This selection means that no temperature compensation is applied.

Dilute NaCl This compensation is based upon pure water with the neutral salt sodium chloride used as the contributor to conductivity. It can be used for measurements below 1000 µS/cm with the temperature range shown in Table 9. Use this compensation for "clean water" applications such as boiler feed, condensate, or RO (reverse osmosis) make up water.

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NaCl This compensation is based upon water with the neutral salt sodium chloride considered as the main contributor to conductivity. Use this compensation for measurements above 1000 µS/cm. It is valid for applications as high as several hundred mS/cm (for example 0-25% NaCl).

Sea Water This compensation is based upon MIL-S-15103F(SH).

KCl This compensation is based upon water with the neutral salt potassium chloride considered as the main contributor to conductivity.

CH$_3$COOH Use this compensation when acetic acid is the main contributor to conductivity. Acetic acid is sometimes used in CIP operations.

H$_3$PO$_4$ Use this compensation when phosphoric acid is the acid constituent. Phosphoric acid is sometimes used in CIP (clean in place) operations.

HCl Use this compensation when hydrochloric acid is the main contributor to the conductivity. A common use of HCl is as a regeneration acid for anion resins. The acid is also used in steel pickling.

H$_2$SO$_4$ These compensations are based upon the activity of sulfuric acid. Three reference temperatures are offered: **25°C**, **30°C**, and **50°C**. Choose the temperature that most closely approximates your application.

Oleum This compensation is based upon the activity of sulfuric acid with dissolved SO$_2$. Use this selection when making measurements in Oleum.

HNO$_3$ Use this compensation when nitric acid is the main contributor to the conductivity. A common use of HNO$_3$ is metal finishing.

NaOH These compensations are based upon the activity of sodium hydroxide dissolved in water (also referred to as caustic or lye). NaOH is also used in CIP (clean in place) operations, demineralization regeneration, and pretzel blanching. Three reference temperatures are offered: **25°C**, **50°C**, and **100°C**. Choose the temperature that most closely approximates your application.

KOH This compensation is based upon the activity of Potassium Hydroxide dissolved in water. Use this selection when potassium hydroxide is the primary constituent of the process.

HF These compensations are based upon the activity of hydrofluoric acid. HF is used in semiconductor, pickling, and etching operations. Two reference temperatures are offered: **0°C** and **25°C**. Choose the temperature that most closely approximates your application.

Green Liquor Kraft green liquor is one of the liquors used in pulp and paper manufacturing. It is formed by adding smelt (recovered chemicals from the digester) to water. Use this selection when measuring conductivity in green liquor in lime slaking operations.

Black Liquor Kraft black liquor is the spent cooking liquor from a sulfate digester in paper mills. Use this selection when measuring conductivity in black liquor as alkali.

Linear Use this compensation for a simple binary solution or when other compensation choices are not appropriate for your application. By entering a linear slope value, between 0.5 and 5%/°C that is representative of your solution's conductivity change with temperature, your analyzer multiplies the factor entered by the temperature deviation times the absolute conductivity. Therefore, if you selected **Linear**, enter the reference temperature (**Ref Temp**) and specify the slope of the linear compensation curve (**Lin Slope**) between 0.5 and 5.0 %/°C.

Custom As with custom measure units, custom temperature compensation requires an explanation before you choose this selection. To prepare a temperature compensation curve, you must select a solution of typical concentration and measure its conductivity in precisely controlled temperature increments. The concentration is usually about 70% of the defined range. For example, if the range is 50 to 23% NaOH, the selected typical concentration might be 30%. However, if there was a concentration critical to the process, then that would be used. The accuracy of the temperature concentration curve is related to the precision of the conductivity measurements at each temperature and the number of data points. A temperature compensation curve of two points would provide only limited compensation. If the process temperature were known to vary between 100 and 170°F, then the conductivity could be measured in 10 degree increments from 90 to 180°F.

After you have done this preparation, select **Custom** as your type of temperature compensation. Then, the prompts ask you to specify a reference temperature (**Ref Temp**) and a number of points to plot a compensation curve. The process-specific compensation data must be generated or extracted in advance of entering it into the analyzer. We suggest that the data be plotted graphically as well as tabularly to prepare it for entry into your analyzer.

In entering the data, the number of points (**Num of Pts**) can be specified from 2 to 21 points. Each point specifies a conductivity value at a certain temperature. The **Temp/Pnt n** temperature units (Celsius or Fahrenheit) are specified under "Temp Unit" on page 56. The **Value/Pnt n** can be specified from 0 to five times the scale value chosen.

> ── **NOTE** ──────────────────────────────────
> When entering data, remember to check the ± sign at the left of your display.

The data should be input to the analyzer with increasing values of temperature.

> ── **NOTE** ──────────────────────────────────
> 1. The temperature values must be entered in increasing or decreasing order or the display will read **Slope Error**.
>
> 2. Actual database saving of the compensation table is not performed until the last point pair is entered.

A maximum or minimum temperature difference between successive temperatures is not required. It is recommended that the data points be equally spaced in the anticipated temperature range.

Figure 20. Configured Conductivity vs. Temperature Data
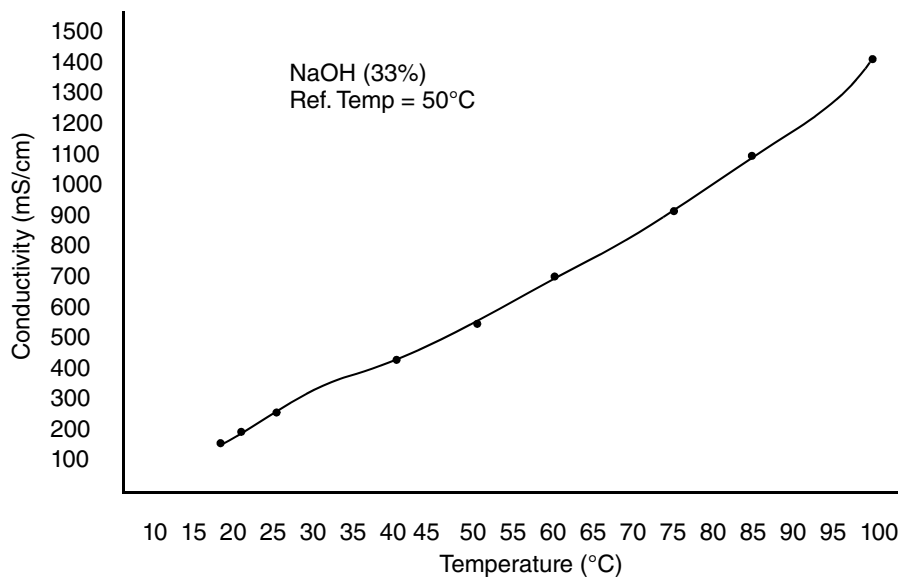
In the example used in Figure 20, the configuration procedure is as follows:

1. Specify the reference temperature. For this example, 50°C.

2. Specify the number of points on your curve. For this example, it is 9.

3. Specify the nine point pairs.

Analog Out (PV), A# Analog Out (PV)

Refer to Figure 36.

This section of the structure enables you to specify what measurement the analog output reflects, the minimum and maximum range values for the output just specified. It also enables you to specify the measurement for the HART secondary, tertiary, and quaternary measurements.

1. First, specify **AO Source Measurement** as **Measurement**, **Temperature**, **Absolute**, **Concentration**, **Cell Resistance**, or **ATC Resistance**.

— **NOTE** —————————————————————————————
Concentration is only available if measurement units was **%** or **Custom**.
——————————————————————————————————————

2. Next, enter the low and high values.

   a. If you are configuring only one application, enter the value of the measurement that produces an output of 4 mA in **Low Value**, and enter the value of the measurement that produces an output of 20 mA in **Upper Value**.

   b. If you are configuring more than one application, enter the value of the measurement that produces an output of 4 mA in **A# Low Value**, and enter the value of the measurement that produces an output of 20 mA in **A# Upper Value** for each application.

The lower and upper values must differ by a minimum amount. Refer to Table 14, Table 15, and Table 16, for minimum and maximum allowable output span. The maximum allowable output setting is equal to the display format.

3. If you are configuring more than one application, specify the Analog Output Endpoints (**A# mA High Value** and **A# mA Low Value**) for each application. The endpoints you specify are hard limits; they cut off overrange from 3.8 to 20.5 mA.

4. Specify the measurements of **HART SV**, **HART TV**, and **HART QV** as **Measurement**, **Temperature**, **Absolute**, **Concentration**, or **ATC Resistance**. The secondary measurement is frequently configured to temperature, the tertiary measurement to Absolute, and the quaternary measurement (if used) to ATC Resistance.

AO Failsafe

Refer to Figure 37.

— **NOTE** ———————————————————————————————

The AO Failsafe parameter does not apply to multidrop communication.

——

A fail-safe output is delivered for those diagnostic failures that have been configured **On** as well as other failures. The AO Failsafe section of the structure enables you to specify the analog output under these fault conditions.

In AO Failsafe, select **Fail Low** to drive the analog output to 3.6 mA; select **Fail High** to drive the analog output to 22 mA; select **Off** to disable this feature (continues to follow the measurement). If **Off** is selected, you can continue to monitor failures using the HART protocol.

⚠ **CAUTION** ————————————————————————————————

It is recommended that this feature be configured to protect your process in case of a fault.

——

Display Format, A# Display Format

Refer to Figure 38.

The Display Format section of the structure enables you to display one, two, or three measurements. Then you can specify what measurement you want on each line of the display.

— **NOTE** ———————————————————————————————

Display Format is not available if measurement units is set to **%** or **Custom**.

——

In **Display Format**, first specify the number of measurements to be displayed by selecting **Single**, **Double**, or **Triple**. Then specify what measurement you want displayed on **Line 1**, **Line 2** (if Double or Triple), and **Line 3** (if Triple).

Figure 21. Measurement Display

1-Line Display

Measurements
345 mS/cm

2-Line Display

Measurements
345 mS/cm — Line 1
31.8 degC — Line 2

3-Line Display

Measurements
345 mS/cm } — Line 1
Line 2 — **25 degC**   **345 mS/cm** — Line 3
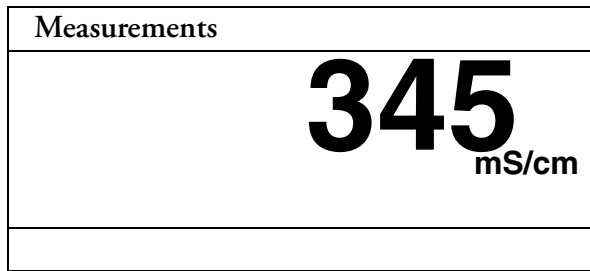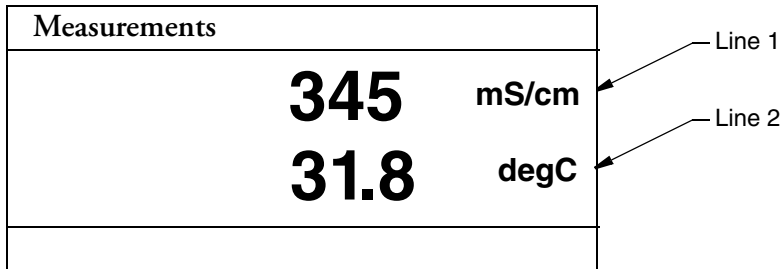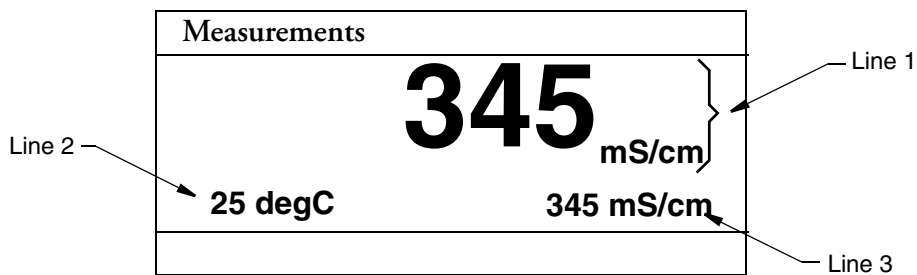
Run Apps

Refer to Figure 39.

─── **NOTE** ──
1. This parameter appears only if the number of applications set in **Number of Apps** was greater than 1.

2. Each application must have been previously configured. Activating a nonconfigured application has no effect.
───

If, in using the transmitter, you wish to change from one application to another, you can specify the application number as **1**, **2**, or **3** in **Run Apps**. The entire application switches to that preconfigured application.

You can also specify **Auto** instead of an application number, and the analyzer switches from one application to another when triggered by measurements above or below established limits. Even though you may be measuring in other units, the high and low limits are always input in mS/cm.

♦ When the measurement value exceeds the **App 1 Hi** preset, **App 2** runs.

♦ When the value then exceeds the **App 2 Hi** preset, **App 3** runs.

♦ When the value decreases below the **App 3 Lo** preset, **App 2** runs.

♦ When the value decreases below the **App 2 Lo** preset, **App 1** runs.

If you specify **Auto**, you must establish the presets which trigger movement from one application to another. Therefore, specify the values of **App 1 Hi**, **App 2 Lo**, **App 2 Hi**, and **App 3 Lo**. These values must be entered in actual values and not in percent. It is assumed that although the ranges of the applications must overlap, application 1 has the lowest conductivity value, application 2 is next, and application 3 has the highest. The switching from one application to another only takes a few seconds. However, once a switch is made, another switch is not allowed for one minute.

HART Digital

Refer to Figure 40.

The HART Digital section of the structure enables you to set parameters for HART communication.

In **Poll Address**:

Enter a number from 0 through 15 if using HART Version 5.

─── **NOTE** ──
In HART Version 5, address 1 through 15 is reserved for multidrop.
───

Enter a number from 0 through 63 if using HART Version 6 or 7.

If using HART Version 6 and 7, enter the **mA Loop Mode** as **Active** or **Multi-Drop**.

Preambles, the number of preambles (5 to 20) to be sent in a response message from the transmitter to the host, are read only.

In **HART Version**, enter the version of the firmware being used.

―――― **NOTE** ――――――――――――――――――――――
The Device Description (DD) must match the HART firmware version.
    HART 5 - - - DD < 14043F
    HART 6 - - - DD > 140440
    HART 7 - - - DD > 14140480

Diagnostics

Refer to Figure 41.

This section of the structure allows you to configure fault messages that can appear on your display. In **Diagnostics**, you can elect to **Enable All** or **Disable All** of the diagnostics or each of the following individually: **Leakage**, **ATC Short**, **ATC Open**, **Comp Range**, **Meas Range**, and **4-20 mA Range**. Each of these is discussed below. A typical approach is to initially disable all of the messages and to enable selected messages later when you find out that you require them. A fault symbol is displayed if a particular diagnostic is enabled and the fault occurs. If the diagnostics detects a failure, the analog output goes to the failsafe value if **AO Failsafe** was configured **On**.

Leakage

This diagnostic reports a problem of severe liquid leakage into the sensor which causes an ATC short to solution ground. The diagnostic can be enabled or disabled.

ATC Short, ATC Open

This diagnostic reports a problem if the resistance of the temperature compensator is greater or less than the expected resistance of the device configured. The diagnostic for each can be enabled or disabled.

Comp Range

This diagnostic reports that the measurement is outside the range configured for the currently running application. The diagnostic can be enabled or disabled.

Meas Range

This diagnostic reports that the measurement tied to the analog output is outside the range configured for the currently running application. The diagnostic can be enabled or disabled. An `Analog out of Range` message is displayed if this diagnostic is enabled and this fault occurs.

Auto Hold

Refer to Figure 42.

The Auto Hold section of the structure enables you to use the automatic hold parameter to automatically activate the Hold feature each time you enter Calibration or Configuration mode. In Auto Hold, select **On Present** to hold all values and states at their current level; **On Manual** to set all values and states at desired levels; or **Off** to omit this feature.

> ── **NOTE** ──────────────────────────────────────
> If you select **On Manual**, you must go to Hold mode to set the values.

Config Timeout

Refer to Figure 43.

The Config Timeout section of the structure enables you to specify the time in which the instrument brings you back to the Measure mode from another mode when no keyboard input has occurred. In Measure mode, **Timeout** also limits the time to view a display other than that configured in "Display Format, A# Display Format" on page 61 that has been temporarily scrolled into view. Timeout can be configured to **Always Timeout**, timeout in online modes only (**Online Only**) or **Never Timeout**. The **Always Timeout** selection is recommended.

The timeout can be configured separately for front panel (**Front Panel**) and (**HART Communications**) operation. The time can be specified from 30 through 999 seconds.

Transmitter Tags

Refer to Figure 44.

The Transmitter Tags section of the structure enables you to enter tags to identify your transmitter. Each can have a maximum number of characters as described below. When you have finished entering a tag, press **ENTER**. These identifications appear in Status mode. For details on entering various characters, see Table 10.

Table 10. Transmitter Tags

Tag Name	Characters
HART Message	32
HART Tag	8
HART Long Tag	32
HART Descriptor	16
Tag Name	14
Location	14
Device Name	6

Passcode Access

Refer to Figure 45.

The Passcode Access section of the structure enables you to limit access to change and/or view various parameters in the firmware. There are two Passcodes; Administrator Code and User Code. A person possessing the Administrator Code can change and view all parameters as well as establish what a person with User Code can access. A person with a User Code can only change and view what the administrator has allowed. Both codes are four digit codes.

> **─ NOTE ─────────────────────────────**
> 1. The initial factory default value for both Administrator and User passcodes is 0800.
> 2. To bypass the passcode, the administrator must configure a passcode of 0000.

The configuration of this section is done in four steps.

1. In **Admin Code**, enter the four digit administrator code from 0 through 9999.

2. In **User Code**, enter the four digit user code from 0 through 9999.

3. In **User Change**, you can elect to enable (**On**) or disable (**Off**) user access to each of the following parameters.

Calibrate	Temp Comp	Apps Config
Analog Out Calib	PV Config	Tags Config
Hold	Meas Config	Timeouts
Suspend Fault	Display Config	Default Config
Resume Fault	Diag Config	Save Config
Clear History	HART Config	

> **─ NOTE ─────────────────────────────**
> You can also make one selection to configure access to all the User Change parameters On or Off.

4. In **User View**, you can elect to enable (**On**) or disable (**Off**) user access to each of the following parameters.

Analog Out Cal	Diags	Xmtr Tags
Temp Comp	HART	Timeouts
Temp Table	Multi Apps	Default

> **─ NOTE ─────────────────────────────**
> You can also make one selection to configure access to all the User Change parameters On or Off.

Stability

Refer to Figure 46.

The **Stability** parameter sets the measurement and temperature stability. It can be set from 25 through 1000%. 25% produces the most stable measurement and temperature measurements. Therefore it causes the longest calibration time. 100% is recommended for new installations.

Restore Configuration

Refer to Figure 47.

Configuring your transmitter involves the setting of many parameters specific for the application. You can configure up to three applications for each profile. In some cases, you may wish to employ the transmitter for more than one application (at different times). Rather than having to change several parameters, the 876EC allows you to save up to two unique and complete configuration profiles including the calibrations associated with these profiles. Either of these two profiles can be restored at any time to facilitate a quick and easy change of the transmitter to a pre-saved configuration. In addition to the two user profiles, the transmitter also includes a "factory default" configuration which allows you to return the transmitter to its original factory configuration at any time.

In **Restore Config**, select **Restore User 1**, **Restore User 2**, or **Restore Factory** and at the question **Restore User 1 Configuration?**, **Restore User 2 Configuration?**, or **Restore Factory Configuration?**, answer **Yes** or **No**.

Diagnostic Mode

Refer to Figure 23. The Diagnostic mode enables you to:

♦ View active faults

♦ View history log

♦ Suspend faults for one hour

♦ Resume any suspended faults

♦ Save two user configurations

To enter Diagnostic mode, press the **FUNCTION** key and then the **DIAG** key. Press **ENTER**. The display returns to Measure mode when you press the **FUNCTION** key and then the **MEASURE** key, or when the timeout period expires. If there are no key presses within the configured timeout period, the transmitter reverts to Measure mode and the outputs remain on hold.

View Faults

Select **View Faults** to view the most severe faults. Use the Up and Down arrow keys to view other faults. Four pieces of information are given for each fault: the type of fault, the severity of the fault, the fault itself, and a factory code (used only to help our Global Customer Support Center identify the cause if you call for help). If there are no faults, the display reads **No Active Faults**. See Figure 22 for a sample display and Table 11 for descriptions of the faults.

Figure 22. Sample View Faults Display
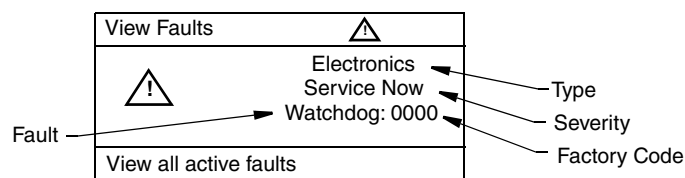
Table 11. List of Possible Faults

Type	Fault	Severity	Corrective Action	Suspendable
Electronics	Analog Calibration Lost	Failed	Contact our Global Customer Support Center	No
	Front End Communications	Service Now		No
	Meas Calibration Lost	Failed		No
	Memory Failure	Most Severe		No
	Memory Write Failure	Most Severe		No
	Operating System	Most Severe		No
	Processor Registers	Most Severe		No
	RAM Failure	Most Severe		No
	Software Failure	Most Severe		No
	Solution Ground Potential	Failed		No
	Temp Calibration Lost	Failed		No
	Watchdog Failure	Most Severe		No
	Elec. T to factory	Service Now	Return to factory	No
	Flash	Failed	Return to factory	No
Config	Temp Comp Table	Failed	Reconfigure Temp Comp Settings. See "Temp Comp" on page 56.	No
SENSOR	Analog Out of Range	Failed	Reconfigure analog output settings	Yes
	ATC Open Circuit	Failed	1.Check ATC wiring and configuration 2. Replace sensor	Yes
	ATC Short Circuit	Failed	1.Check ATC wiring and configuration 2. Replace sensor	Yes
	Measurement Overflow	Failed	Contact our Global Customer Support Center	No
	Sensor Leaking	Failed	Replace sensor	Yes
	Temperature OOR	Failed	1. Check ATC wiring and configuration 2. Replace sensor	Yes
	Temp Comp OOR	Service Now	Reconfigure temperature compensation settings	Yes
	Concentration OOR		Reconfigure the concentration parameter	
	Temp Sensor 3rd Wire	Service Now	1. Check ATC configuration 2. Connect 3rd wire of temp sensor	Yes
Calib	Calibration Required A1 Calibration Required A2 Calibration Required A3 Calibration Required	Service Now	Perform measurement calibration	No
	Out of Range		Check Sensor wiring	No

View History Log

Select **History** Log and press **ENTER** to view or erase the diagnostic history logs. Use the Up and Down arrow keys to select All History Logs, Calibration Log, Error Log, Operation Log. You can also select Clear History; however clearing the history log requires entering your passcode.

Suspend or Resume Faults

Select **Suspend Faults** to suspend the present faults for one hour. The display asks for your passcode. An incorrect passcode returns you to the start of the Diagnostic menu. A correct passcode causes the prompt **Suspend Fault?** to be displayed. If you answer **Yes**, the message **Faults Suspended** is displayed. After either a **Yes** or **No** reply, the Diagnostic menu is displayed. Each suspended fault is inhibited from reoccurring for one hour from the time the Diagnostic mode is entered.

The faults listed in Table 11 as "Suspendable" can be suspended and resumed as necessary. Select **Suspend Faults** to suspend the present faults for one hour.

Select **Resume Faults** to resume all suspended faults.

Save User Configuration

Configuring your transmitter involves the setting of many parameters specific for the application. In some cases, you may wish to employ the transmitter for more than one application (at different times). Rather than having to change several parameters, the 876EC allows the user to save up to two unique and complete configuration profiles including the calibrations associated with these profiles.

Either of these two profiles can be restored at any time to facilitate a quick and easy change of the transmitter to a pre-saved configuration. See "Restore Configuration" on page 67.

Select **Save Config 1** or **Save Config 2** to save your configuration. The display asks for passcode. An incorrect passcode returns you to the start of the Diagnostic menu. A correct passcode causes the prompt **Save Config #?** to be displayed. If you answer **Yes**, the message **Configuration Saved** is displayed. If you answer **No**, the message displayed is **Action Cancelled**.

Figure 23. Diagnostic Mode Structure
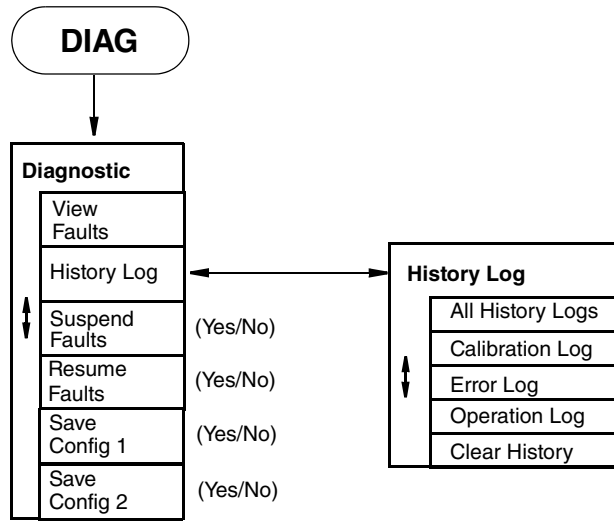
6. Operation Via HART Communicator

> **NOTE**
>
> 1. For HART communications, a 250 Ω load resistor must be present in the power supply loop.
>
> 2. For proper communication with a HART Communicator, the communicator must contain the proper DD for the 876EC Transmitter. This DD is available from our website or any other authorized HART Foundation source.
>
> 3. If the DD shows "access restricted", start over and re-enter the passcode.

Entering Modes

From the Home menu, select the mode to be entered. If `Save to Xmtr` appears, it must be handled before entering a different mode. If a passcode is required, select `Enter Passcode` before accessing a new mode.

Saving Changes

Changes must be saved before going to another mode.

If the `Send` soft key appears on the screen, press it twice before saving changes.

Press `Home`, select `Save to Xmtr`. Answer the `Save changes?` question by selecting `Yes` or `No`, and pressing `ENTER`. If errors exist, the `Fix Errors?` question appears. A `No` response discards all changes; An `Yes` response provides the title of the first parameter with a problem which must then be resolved.

> **NOTE**
>
> The `Save` soft key refers to a local communicator copy of the parameters, not the transmitter's `Save changes`.

HART Online Menu

Figure 24. 876EC Transmitter Online Menu Tree (1 of 2)
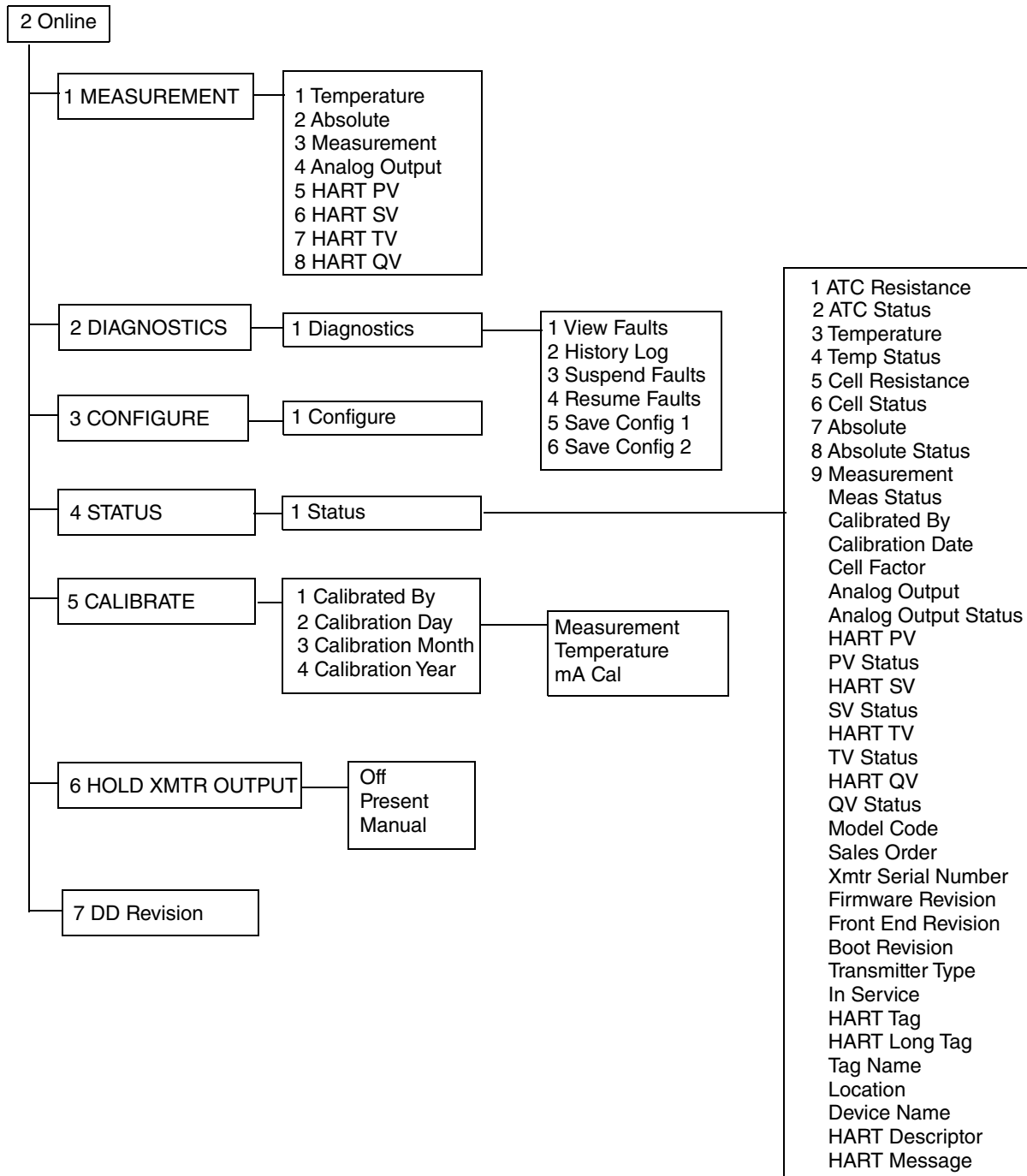
(a) In the DD, these measurements and units may not stay up-to-date with multiple application switching in the transmitter.

Figure 25. 876EC Transmitter Online Menu Tree (2 of 2)

CONFIGURATION[a]

1 Sensor Type	1 871EC 2 871FT English 3 871FT Metric 4 EP307 5 FT10 6 Other

2 *<Sensor>* Type[b]

3 Temp Type

4 Meas Config	1 Meas Units 2 Base Display Scale 3 Damping

5 Temp Config	1 Temp units 2 Temp Mode 3 Manual Temp 　or Fail Temp

6 Temp Comp	Absolute Dilute NaCl NaCl Sea Water KCl CH_3COOH H_3PO_4 HCl H_2SO_4 Oleum HNO_3 NaOH KOH HF Green Liquor Black Liquor Linear Custom

7 Analog Out	1 AO Source 2 Upper Value 3 Low Value 4 HART SV 5 HART TV 6 HART QV

8 AO Failsafe	Off Fail Low Fail High

9 Meas Display	1 Display Format 2 Line 1 3 Line 2 4 Line 3

HART Digital	1 Poll Address 2 mA Loop Mode 3 Preambles 4 HART Version

Diagnostics	1 Enable/Disable Diag

Auto Hold	Off On Present On Manual

Timeout	1 Timeout

Transmitter Tags	1 HART Tag 2 HART Long Tag 3 HART Descriptor 4 HART Message 5 Tag Name 6 Device Name 7 Location

Passcode Access	1 Admin Code 2 User Code 3 User Change 4 User view

Stability

Restore Config	1 Restore User 1 2 Restore User 2 3 Restore Factory

(a) In the DD, these measurements and units may not stay up-to-date with multiple application switching in the transmitter.
(b) This field displays 871EC Type, 871FT Type, or FT10 Type, depending on Sensor Type chosen in previous field.

Explanation of Parameters

- **NOTE**

1. The fast-key path shown is based on a frequently used configuration. If certain parameters are configured off or infrequently used parameters configured on, the fast-key path may be different.

2. For more detailed explanation of parameters, see "Operation Via Local Display" on page 25.

Parameter	Fast-Key Path	Explanation
Measurement Mode		
Absolute	1,2	Displays the absolute (uncompensated) measurement value
Analog Output	1,4	Displays the analog output in mA
HART PV	1,5	Displays the HART primary value
HART QV	1,8	Displays the HART fourth value
HART SV	1,6	Displays the HART secondary value
HART TV	1,7	Displays the HART tertiary value
Measurement	1,3	Displays the measurement (PV) value
Temperature	1,1	Displays the temperature value in specified engineering units
Diagnostic Mode		
History Log	2,2	Used to view or erase one or more diagnostic history logs
Resume Faults	2,4	Used to resume suspended faults
Save Config 1	2,5	Used to save your configuration
Save Config 2	2,6	Used to save your configuration
Suspend Faults	2,3	Used to suspend faults for one hour
View Faults	2,1	Displays the most severe fault and other faults if desired
Configure Mode		
Sensor Type	3,1	Used to specify an 871EC, 871FT English, 871FT Metric, EP307, FT10, or Other sensor type
871EC Type, 871FT Type, or FT10 Type	3,2	Used to specify the type of 871EC, 871FT, or FT10 sensor
Temp Type	3,3	Used to specify the temperature type as 2-Wire Pt 100, 2-Wire Pt 1000, 3-Wire Pt 100, 3-Wire Pt 1000, Mil RTD, or 100K Thermistor
Meas Config	3,4	Path to measure related parameters
Temp Config	3,5	Path to temperature related parameters
Temp Comp	3,6	Used to specify temperature compensation
Analog Out (PV)	3,7	Path to analog output related parameters
AO Failsafe	3,8	Used to specify the analog output under fault conditions
Meas Display	3,9	Path to display related parameters
HART Digital		Path to HART related parameters
Diagnostics		Path to diagnostic related parameters
Auto Hold		Used to configure all values and states to be held at their current level (On Present), at a desired level (On Manual) when triggered by a digital signal or when going into Calibration or Configuration mode. Select Off to omit this feature
Config Timeout		Used to specify the time in which you are returned to Measure mode when no keyboard input has occurred
Transmitter Tags		Path to tag related parameters

Parameter	Fast-Key Path	Explanation
Passcode Access		Path to passcode related parameters
Restore Config		Path to restoring the transmitter to a user stored or the factory configuration
Measurement	3,1,1	Select the type of measurement
Damping		Enter the damping response time
Temp Units	3,3,1	Select Temp Units as °C or °F
Temp Mode	3,3,2	Select the Temp Mode as Auto or Manual
Manual Temp	3,3,3	If Temp Mode is Manual: Enter a fixed temperature
Fail Temp	3,3,3	If Temp Mode is Auto: Enter a temperature fail signal value
AO Source	3,5,1	Select the AO Source from the picklist provided
Low Value	3,5,2	Enter the measurement value that is to produce 4 mA
Upper Value	3,5,3	Enter the measurement value that is to produce 20 mA
HART SV	3,5,4	Select the SV measurement from the picklist provided
HART TV	3,5,5	Select the TV measurement from the picklist provided
HART QV	3,5,6	Select the QV measurement from the picklist provided
Display Format	3,6,1	Select the Display Format as Single, Double, or Triple
Line 1	3,6,2	Select the measurement to be displayed on Line 1
Line 2	3,6,3	Select the measurement to be displayed on Line 2
Line 3	3,6,4	Select the measurement to be displayed on Line 3
Poll Address	3,8,1	For HART version 5: Enter the polling address to a number from 0 through 15. A nonzero number specifies multidrop applications For HART version 6 and 7: Enter the polling address to a number from 0 through 63
Preambles	3,8,2	Displays the number of preambles to be sent in a response message from the transmitter to the host
HART Version	3,8,3	Used to specify the HART version
Enable/Disable Diag	3,9,1	Turn On or Off the various diagnostics
HART Message		Enter a HART Message (32 characters maximum)
HART Tag		Enter a HART Tag (8 characters maximum)
HART Long Tag		Enter a HART Long Tag (32 characters maximum)
HART Descriptor		Enter a HART Descriptor (16 characters maximum)
Tag Name		Enter a Tag Name (14 characters maximum)
Location		Enter a Location (14 characters maximum)
Device Name		Enter a Device name (6 characters maximum)
Admin Code		Enter a 4-digit Administrator Code
User Code		Enter a 4-digit User Code
User Change		Turn On or Off the various parameters the user is allowed to change
User View		Turn On or Off the various parameters the user is allowed to view
Buffer Set		Select the Buffer from the picklist provided
Stability		Enter a value (%) for measurement/temperature stability
Restore User 1		Enables you to restore a saved user configuration
Restore User 2		Enables you to restore a saved user configuration
Restore Factory		Enables you to restore the factory configuration
Status Mode		
Temperature	4,1,1	Displays the temperature measurement
Temp Status	4,1,2	Displays the status of the temperature measurement
Absolute	4,1,3	Displays the absolute measurement
Absolute Status	4,1,4	Displays the status of the absolute measurement

Parameter	Fast-Key Path	Explanation
Temp Sensor	4,1,5	Displays the temperature sensor resistance
T Sensor Status	4,1,6	Displays the status of the temperature sensor
Measurement	4,1,7	Displays the measurement
Meas Status	4,1,8	Displays the status of the measurement
Calibrated By		Displays the name of the last operator
Calib Date		Displays the date of last calibration (dd/mm/yyyy)
Analog Output		Displays the value of the analog output
Analog Output Status		Displays the status of the analog output
HART PV		Displays the HART primary value
PV Status		Displays the status of the HART primary value
HART SV		Displays the HART secondary value
SV Status		Displays the status of the HART secondary value
HART TV		Displays the HART tertiary value
TV Status		Displays the status of the HART tertiary value
HART QV		Displays the HART fourth value
QV Status		Displays the status of the HART fourth value
Model Code		Displays the transmitter model code
Sales Order		Displays the transmitter sales order number
Xmtr Serial Number		Displays the analyzer serial number
Firmware Revision		Displays the firmware revision level
Front End Revision		Displays the front end revision level
Boot Revision		Displays the boot revision level
Transmitter Type		Displays the transmitter type (876EC)
In Service		Displays the time in service in days
HART Tag		Displays the HART Tag name
HART Long Tag		Displays the HART Long Tag name (versions 6 and 7)
Tag Name		Displays the tag name
Location		Displays the location of the measurement
Device Name		Displays the device name
HART Descriptor		Displays the HART descriptor
HART Message		Displays the HART message
Calibrate Mode		
Calibrated By	5,1	Enter the name of the person calibrating the device and the date of calibration
Calibration Day		Enter the day of the calibration
Calibration Month		Enter the month of the calibration
Calibration year		Enter the year of the calibration
mA Cal		Used to perform a mA Cal calibration
Measurement		Used to perform a measurement calibration
Temperature		Used to perform a temperature calibration
Hold Xmtr Output		
Off		Used to release the transmitter from Hold state
On Present		Used to hold all values and states at their current level
On Manual		Used to hold all values and states at desired levels
DD Revision		Displays the DD Revision level

7. Maintenance

This product contains components that have critical safety characteristics. **Do not** substitute components. Replace components only with identical factory supplied components. Component substitution may impair the electrical safety of this equipment and its suitability for use in hazardous locations.

The maintenance of the 876EC Transmitter is limited to replacement of the bezel/keypad assembly, the display printed wiring assembly (PWA), the processor PWA and the loop power (MAU) PWA. Attempts to repair printed wiring assemblies could result in damage and voiding of the warranty. The recommended repair procedure is return of the transmitter to the factory for repair. For additional information, refer to PL 611-260.

To replace parts, refer to Figure 26.

Figure 26. Exploded View of 876EC Transmitter

SAFETY COVER CAUTION LABEL   JUMPER LABEL
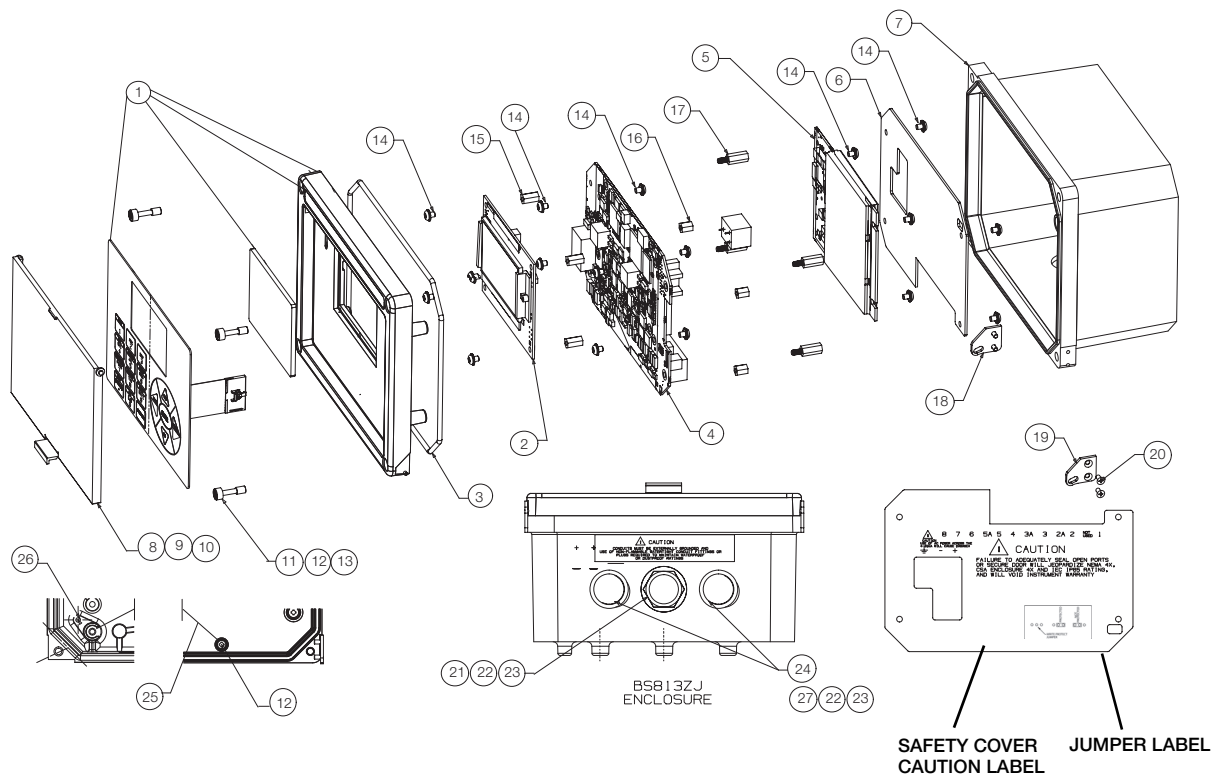
Before replacing parts, be sure to turn power off.

NOTICE

This unit uses printed wiring assemblies with components that are **highly susceptible to damage from electrostatic discharge (ESD)**. Relatively low static potential can rupture sensitive components resulting in degraded device characteristics or failure. All printed wiring assemblies **must** be handled with the user grounded via a conductive wrist strap (between 100 Ω minimum and 1 MΩ maximum).

Replacing the Bezel/Keypad Assembly (Item 1)

1. Unscrew the four Screws (Item 11) on the corners of the bezel/keypad assembly and open the assembly downward.

NOTICE

The assembly does not open a full 180°. Do not press on it.

2. Remove four Screws (Item 14) and remove the Safety Cover (Item 6).

3. Remove four Standoffs (Item 17), disconnect the ribbon cable, and carefully lift off stack of boards.

4. Remove screw (Item 26) that secures the ground wire (Item 25) to the bezel/keypad assembly (Item 1).

5. Remove one of the two door Hinges (Item 18 or 19) by removing the two Screws (Item 20) that secure it. Remove the door.

6. Install the new door by reversing Steps 1 though 5.

⚠ CAUTION

When positioning stack of boards on the bezel/keypad assembly bosses, carefully fold the flex ground strap over the lower left boss.

Replacing the Loop Power (MAU) PWA (Item 5)

1. Unscrew the four screws (Item 1) on the corners of the bezel/keypad assembly and open the assembly downward.

NOTICE

The assembly does not open a full 180°. Do not press on it.

2. Disconnect wires from power terminals.

3. Remove four Screws (Item 14) and remove the Safety Cover (Item 6).

4. Remove the four Screws (Item 14) that secures the MAU PWA (Item 5) to the Standoffs (Item 16).

5. Grasping the MAU PWA on both sides, carefully lift it straight up and off.

6. Install the new MAU PWA by reversing Steps 1 though 5.

Replacing the Processor PWA (Item 4)

1. Remove the MAU PWA as described immediately above.

2. Disconnect wires from sensor terminals.

3. Remove the four Screws (Item 14) that secures the Processor PWA (Item 4) to the Standoffs (Item 15).

4. Remove four Standoffs (Item 17) and save them.

5. Carefully separate the Processor PWA (Item 4) and Display PWA (Item 7).

6. Remove the four Screws (Item 14) and Standoffs (Item 16) from the Processor PWA (Item 4) and save them.

7. Install the new Processor PWA by reversing Steps 1 though 6.

Replacing the Display PWA (Item 2)

1. Unscrew the four screws (Item 14) on the corners of the bezel/keypad assembly and open the assembly downward.

NOTICE

The assembly does not open a full 180°. Do not press on it.

2. Disconnect wires from power terminals.

3. Remove four Screws (Item 14) and remove the Safety Cover (Item 6).

4. Remove four Standoffs (Item 17), disconnect the ribbon cable, and carefully lift off stack of boards.

5. Remove the four screws (Item 14) that secures the Display PWA to Standoffs (Item 15).

6. Carefully separate the Processor PWA (Item 4) and Display PWA (Item 2).

7. Install the new Display PWA by reversing Steps 1 though 6.

Appendix A. Calibration Guidelines and Examples

Measurement calibration offers a variety of options for calibrating the loop (the transmitter, the cabling, and the sensor) in conductivity or concentration units. If more than 1 application has been selected in **CONFIG**, the calibration procedure allows you to select the application number to which to apply the calibration. Before the calibration procedure can be carried out, you must determine which options are most appropriate to your process, since some of these options need to be selected when prompted in the calibration menu.

> ─ **NOTE** ──────────────────────────
> Before starting a measurement calibration procedure:
> 1. Choose the calibration method and equipment that is best for your application.
> 2. Choose a 1-point or 2-point calibration.
> 3. Choose a **Process** or **Manual** calibration.
> 4. Determine conductivity or concentration values for the calibration point(s).
> 5. If **Manual** is chosen, decide on the "Solution" or "Bench" option.
> 6. If Bench is chosen, calculate resistance(s) that simulate the selected solution conductivity value(s).

The following sections provide guidance to help you select the most efficient method of carrying out the measurement calibration procedure depending on your sensor type and your process.

Calibration Methods and Equipment

Loop(s) of User-Supplied Wire with Decade Resistance Box

Although a loop or loops of wire can be used to calibrate any type of electrodeless sensor, this technique is best suited to invasive sensors such as the 871EC Series, since it is simple to loop the wire through the bore or "donut" in the sensor. A wire loop can be threaded through the bores of flow-through sensors such as the 871FT, but it is not as simple, and as these sensors have connection ports to accept a Foxboro Calibration Cable or Calibration Plug, those options are preferred, and they are described below.

Figure 27 depicts a loop of wire connected to a decade resistance box and looped once through the bore of an 871EC-type sensor. For best results calibrating with loops of wire, follow these recommendations:

1. An invasive sensor should be suspended in air, at least 6 in (15 cm) away from all objects. A flow-through sensor should be removed from the process to a suitable location such as a lab or work bench.

2. AWG 16 or heavier (lower AWG) wire gauge should be used for best results.

3. A precision, calibrated decade resistance box or discrete metal-film resistor should be used.

Figure 27. Connection of Resistance Using Loop of Wire and Decade Resistance Box
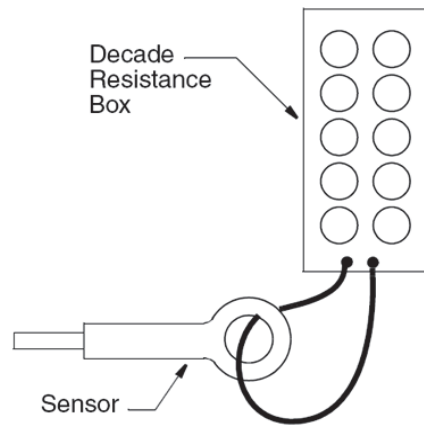
Foxboro Calibration Plugs

Foxboro Calibration Plugs come in two types depicted in Figure 28. Calibration Plugs are integrated assemblies containing precision resistors that make calibration of all types of EC measurement loops fast, simple, convenient, and reliable. Model EP485A and EP485F plugs plug directly into the connection port of 871FT and FT10 Series flow-through sensors, respectively. EP485Q plugs provide a loop of wire for looping through invasive EC sensors like the 871EC. Foxboro Calibration Plugs are custom configured to resistance values specified in each customer order.

For best results calibrating with Foxboro Calibration Plugs, follow these recommendations:

1. An invasive sensor should be suspended in air, at least 6 in (15 cm) away from all objects.

2. A flow-through sensor should be removed from the process to a suitable location such as a lab or work bench, or, if left installed, should be flushed with air or a solution having a conductivity at least 1000 times lower than the calibration conductivity value.

Figure 28. Calibration Plugs

EP485A Calibration Plug with 871FT Sensor   EP485Q Calibration Plug with 871EC Sensor

Foxboro Calibration Cable with Decade Resistance Box

Foxboro flow-through sensors such as the 871FT and FT10 Series are equipped with a connection port that allows direct connection of a resistance using a Foxboro Calibration Cable (PN BS807BD). This connection accesses a single loop or multiple loops of wire that pass through the sensor bore internally. The other end of the cable can be connected to a resistor or decade resistance box as shown for the user-supplied wire. Calibration can take place without uninstalling the sensor from the process. For best results calibrating with the Foxboro Calibration Cable, follow these recommendations:

1. Use the Calibration Cable only for resistances less than 1.5 kΩ. For higher resistances, Foxboro Calibration Plugs are recommended.

2. The sensor should be removed from the process, or, if left installed, should be flushed with air or a solution having a conductivity at least 1000 times lower than the calibration conductivity value.

3. A precision, calibrated decade resistance box or discrete metal-film resistor should be used.

4. If the sensor is an 871FT, its date of manufacture must be determined. The date of manufacture is determined from the last four digits of the Origin Date Code found on the sensor data plate. A code of 2B0149 means the sensor was manufactured in week 49 of 2001. Sensors with Origin Date Codes of 2B9710 or later have 5 wire loops through the bore, so n = 5 in the resistance equation above. For sensors manufactured earlier than 2B1049, n = 1.

EP402 Calibration when Connected to an 876EC

Precalibration Procedure

1. Verify that the large bore PEEK sensor being used is appropriate for the desired conductivity range.

2. Verify that the temperature compensation curve being used in the analyzer or transmitter is correct. For example, select Dilute NaCl for a condensate measurement (or water < ~1000 μS/cm); NaOH for a caustic measurement).

3. Verify that the analyzer or transmitter is configured for the appropriate temperature element provided by the EP402 Assembly; for example, 100 Ω RTD.

4. Verify that the 871EC sensor has been degaussed if measurement is to be <500 μS.

5. Calculate the full scale range resistance, using the formula:
    R in ohms = $(Cf_{(geom)} \times 1000) / (Full\ Scale\ in\ mS/cm)$

> **— NOTE ————————————————————**
> Use the geometric cell factor from Table 12. Do **not** use the cell factor of the 871EC Large Bore PEEK Sensor.

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Table 12. Cell Factors

Model Code	Line Size	$Cf_{(geom)}$
EP402A	1/4 inch	1.42 cm^{-1}
EP402B	3/8 inch	1.28 cm^{-1}
EP402C	1/2 inch	1.14 cm^{-1}
EP402D	5/8 inch	1.09 cm^{-1}
EP402E	5/8 inch	6.41cm^{-1}
EP402H	1/4 inch	1.56 cm^{-1}
EP402J	3/32 inch	8.52 cm^{-1}

Electronic Bench Calibration

1. In the Configuration menu, select **871EC** for the Sensor Type, then specify appropriate sub-type (**LB**, **UT**, or **RE**).

2. Select desired **Base Display Scale** in the 876EC Configuration menu.

3. Enter Calibration mode. Select **Measurement** and **Manual**.

4. Disconnect the wire strap from one side of the EP402 Assembly.

5. With an empty EP402 Assembly (infinite resistance), enter the low value **0.0** µS/cm, mS/cm, S/cm, depending on the desired range.

6. Reconnect the wire strap and route a loop of wire through the EP402 Assembly (or use the calibration wire) and connect to a decade resistance box.

7. Set the resistance to the value calculated in the precalibration procedure using $Cf_{(geom)}$ in Table 12.

8. Enter the full scale value and accept the calibration.

9. Reinstall the EP402 Assembly into the process line.

Calibration Using a Known Solution

1. In the Configuration menu, select **871EC** for the Sensor Type, then specify appropriate sub-type (**LB**, **UT**, or **RE**).

2. Select desired **Base Display Scale** in the 876EC Configuration menu.

3. Enter Calibration mode. Select **Measurement** and **Process**.

4. With the wire strap disconnected from one side of the EP402 Assembly or with the EP402 Assembly filled with a solution having 1000-fold less conductivity than the desired full scale, enter the low value **0.0** µS/cm, mS/cm, or S/cm, depending on the desired range.

5. Reconnect the wire strap if it was disconnected in the previous step. Fill the EP402 Assembly with a solution having known conductivity at the existing temperature, or measure the conductivity independently using a grab sample.

6. Enter the known conductivity value and accept the calibration.

7. Reinstall the EP402 assembly into the process line.

Open Air Calibration

In some cases, you can use "open air" (a conductivity value of 0) as the low calibration point when performing a measurement calibration. Although this is convenient and generally acceptable for wide ranging applications, using open air as the low calibration point is not as accurate as using two precision resistance inputs to perform a measurement calibration.

When considering an open air calibration:

♦ The conductivity value used for the high calibration point must be greater than or equal to the value in the "Minimum Allowed High Calibration Value" column in Table 13.

♦ Resulting accuracy when using open air for the low calibration point is provided in the "Open Air Accuracy" column in Table 13.

Table 13. 876EC Open Air Calibration Guidelines

Sensor Type	Minimum Allowed High Calibration Value (mS/cm) (a)	Open Air Accuracy (mS/cm)
871EC and EP307 Sensors		
871EC-SP, HP	43.000	0.717
871EC-PP, PT	43.000	0.717
871EC-RE, BW	8.800	0.147
871EC-LB, UT	3.400	0.057
871EC-TF	46.200	0.770
871EC-NL	47.000	0.783
871EC-EV	9.000	0.150
871EC-AB	11.760	0.196
871EC-PN, PX	49.000	0.817
EP307B	49.000	0.817
EP307T	49.000	0.817
EP307G	49.000	0.817
871FT Sensors		
871FT-1C	116.000	1.933
871FT-1D	41.400	0.690
871FT-1E	26.700	0.445
871FT-1F	11.100	0.185
871FT-1G	6.210	0.104
871FT-1H	3.770	0.063
871FT-1J	2.080	0.035
871FT-2C	45.313	0.755
871FT-2D	16.172	0.270
871FT-2E	10.430	0.174
871FT-2F	4.336	0.072
871FT-2G	2.426	0.040
871FT-2H	1.473	0.025
871FT-2J	0.813	0.014
871FT-3C	60.400	1.007

Table 13. 876EC Open Air Calibration Guidelines (Continued)

Sensor Type	Minimum Allowed High Calibration Value (mS/cm) (a)	Open Air Accuracy (mS/cm)
871FT-3E	21.200	0.353
871FT-3F	9.700	0.162
871FT-3G	9.700	0.162
871FT-3H	5.080	0.085
871FT-3J	3.060	0.051
871FT-4C	11.800	0.197
871FT-4E	4.141	0.069
871FT-4F	1.895	0.032
871FT-4G	1.895	0.032
871FT-4H	0.992	0.017
871FT-4J	0.598	0.010
FT10 Sensors		
FT10-08	109.800	1.830
FT10-12	30.800	0.513
FT10-16	24.200	0.403

a. The display scale should be at least high enough to cover this value. For example, "43" requires a display scale of 99.99 or higher.

1-Point and 2-Point Calibrations

You can carry out 1- or 2-point conductivity or concentration measurement calibrations. A 2-point calibration must be carried out before a 1-point can be used. This is because the 2-point calibration is necessary for the transmitter to calculate an offset value and adjusted Cell Factor (analogous to "slope" or "gain"). A subsequent 1-point calibration then serves as an offset adjustment only. The adjusted Cell Factor, calculated in the 2-point calibration, is unaffected by subsequent 1-point calibrations.

Process and Manual Calibrations

The **Process** option takes advantage of the selected temperature compensation. It is not relevant or present in the menu when **Absolute** is selected under **Temp Comp** in the **CONFIG** menu. In **Process** calibration, you enter values for the calibration solution(s) in the units selected for display (conductivity or concentration) *corresponding to the reference temperature* (**Ref Temp**). If the calibration temperature is different from the reference temperature, the transmitter will apply the appropriate compensation.

In **Manual**, there are two options for providing known conductivity values to the transmitter: Solution (actual solutions) or Bench (fixed resistances). By convention, this document uses the terms **Manual**/Solution and **Manual**/Bench to refer to these two options.

With **Manual**/Solution, the absolute conductivity of the solution(s) *at the actual temperature of calibration* must be entered in the conductivity units chosen under **Base Units**, even if units of concentration have been chosen for display and output. With **Manual**, you must know the conductivity values of the chosen solutions at all temperatures expected during calibration. **Manual** can be used with any **Temp Comp** setting, including **Absolute**.

With **Manual**/Bench, the conductivity value corresponding to the calculated fixed resistance is entered.

Instructions for calculating fixed resistances for **Manual**/Bench calibrations can be found in "Calculating Resistance Values" on page 95.

> ─ **NOTE** ───
> The following factors should be considered when choosing between **Process**, **Manual**/Solution, and **Manual**/Bench options.
>
> 1. **Process** is advantageous when **Temp Comp** for the process is well established. This will be true in any case where the pre-programmed Foxboro **Temp Comp** curves are used. Calibration can take place outside of the process with solutions that match or simulate the process solution, or the sensor can remain in the process and calibration value(s) can be obtained by analysis of a grab sample or other process data available.
>
> 2. **Process** is advantageous when it is not feasible to uninstall an invasive sensor such as the 871EC Series from the process, and, as above, well-established **Temp Comp** curves exist for the process.
>
> 3. **Process** or **Manual**/Solution calibrations are possible, but inconvenient, with flow-through sensors. Whereas invasive sensors can easily be dipped into vessels of standard solution, flow-through sensors such as the 871FT and FT10 Series require provisions to enable filling, emptying, and flushing. Therefore, **Manual**/Bench calibration is recommended for flow-through sensors.
>
> 4. **Manual**/Bench calibration is generally speaking the most convenient and foolproof technique, since solutions do not have to be handled or maintained. It is applicable when invasive sensors can feasibly be removed from the process, or when flow-through sensors such as the 871FT or FT10 Series are in use, as these sensors have calibration ports that allow Bench calibration while remaining installed in the process.

5. Manual/Solution calibration is advantageous when it is feasible to uninstall a sensor and well-established process **Temp Comp** curves are unavailable, but reliable conductivity standards with known temperature curves are available for use outside the process.

6. Manual/Bench calibration requires calculation of resistance values that simulate the desired conductivity values. These calculations are described under "Calculating Resistance Values" on page 95.

7. You may wish to utilize more than one calibration technique. For example, when setting up a conductivity loop (transmitter + cabling + sensor), it may be convenient to carry out a 2-point **Manual**/Bench calibration. Then 1-point **Process**, **Manual**/Solution, or **Manual**/Bench calibrations may be used to maintain the loop.

Determining Conductivity Calibration Values

Two "solutions" must be chosen as calibration points. In a **Process** or **Manual**/Solution calibration, these will be actual solutions in which an invasive sensor will be dipped or with which a flow-through sensor will be filled. In a **Manual**/Bench calibration, these are not actual solutions but resistors that simulate actual solution conductivities.

Refer to Table 14, Table 15, and Table 16 to aid in selection of conductivity calibration values for the sensor in use.

In most cases:

♦ Calibration values should bracket the measurement ranges expected in the process

♦ Calibration values should be within the range of the sensor (Table 14, Table 15, and Table 16)

♦ Calibration values should be within the selected display range

♦ Calibration values should differ by at least a factor of 3 so that the most accurate calibration calculations to be carried out by the transmitter.

In addition, if the process is being controlled to a set point, one of the calibration points should be near the set point.

To use these tables:

1. Find your sensor in the Sensor Type column, and the configured units in the Selected Units column.

    If you are working with conductivity values, the units in this column of the table correspond to Meas Units. If you are working with concentration or custom Meas Units, the units correspond to the configured Base Units. See Figure 33.

2. Following the row with your sensor type and units, find the cells that correspond to your configured display format. The display format is equivalent to the maximum allowable output setting.

Consider an example where you want to calibrate an 871EC SP sensor according to application limits of 0 to 1000 μS/cm, and the Base Display Scale chosen is 999.9. An appropriate calibration range is 215.0 to 7,166.7:

871EC Sensor Type	Selected Units	Selected Display Format										Minimum Allowable Output Span
		0.9999		9.999		99.99		999.9		9999		
		Low	High	Low	High	Low	High	Low	High	Low	High	
HP, PP, PT, SP	μS/cm							215.0	7,166.7	717	5,375,000	323
	mS/m					21.50	716.67	71.7	537,500.0	72	537,500	32.3
	mS/cm	0.2150	7.1667	0.717	5,375.000	0.72	5,375.00	0.7	5,375.0	1	5,375	0.323
	S/m	0.0392	8.6000	0.072	537.500	0.07	537.50	0.1	537.5	0	538	0.0323

This means that the lowest the low calibration point can be is 215.0 μS/cm, and the highest the high calibration point can be is 7,166.7 μS/cm. In this case, you may want to use 300 μS/cm for the low calibration point and 1000 μS/cm for the high calibration point. The same calibration points could be used if you were working with concentration values of an 871EC SP sensor (Meas Units of % and Base Units of μS/cm).

As another example, assume you are working with conductivity values of an 871EC SP sensor with a Base Display Scale of 999.9 mS/cm. In this case, an appropriate calibration range is 0.7 to 5,375 mS/cm.

871EC Sensor Type	Selected Units	Selected Display Format										Minimum Allowable Output Span
		0.9999		9.999		99.99		999.9		9999		
		Low	High	Low	High	Low	High	Low	High	Low	High	
HP, PP, PT, SP	μS/cm							215.0	7,166.7	717	5,375,000	323
	mS/m					21.50	716.67	71.7	537,500.0	72	537,500	32.3
	mS/cm	0.2150	7.1667	0.717	5,375.000	0.72	5,375.00	0.7	5,375.0	1	5,375	0.323
	S/m	0.0392	8.6000	0.072	537.500	0.07	537.50	0.1	537.5	0	538	0.0323

This calibration range is also appropriate if you are working with concentration values of an 871EC SP sensor with Meas Units = % and Base Units = mS/cm.

The following sections provide the data you need to select low and high calibration points for your sensor type, units, and display format.

871EC and EP307 Sensor Types

Table 14. 871EC and EP307 Ranges and Minimum Allowable Output Span for Selected Sensor, Units, and Display Format

871EC and EP307 Sensor Type	Selected Units (a)	Selected Display Format (b) Low and High Limits of 1% Accuracy Range (c)										Min. Allow. Output Span
		0.9999		9.999		99.99		999.9		9999		
		Low	High	Low	High	Low	High	Low	High	Low	High	
AB	µS/cm							79.4	5,880.0	196	1,470,000	68
	mS/m					7.94	588.00	19.6	147,000.0	20	147,000	6.8
	mS/cm	0.0794	5.8800	0.196	1,470.000	0.20	1,470.00	0.2	1,470.0	0	1,470	0.068
	S/m	0.0196	147.0000	0.020	147.000	0.02	147.00	0.0	147.0			0.0068
EV	µS/cm							79.4	5,880.0	196	1,470,000	88
	mS/m					7.94	588.00	19.6	147,000.0	20	147,000	8.8
	mS/cm	0.0794	5.8800	0.196	1,470.000	0.20	1,470.00	0.2	1,470.0	0	1,470	0.088
	S/m	0.0196	147.0000	0.020	147.000	0.02	147.00	0.0	147.0			0.0088
BW, RE	µS/cm							59.4	4,400.0	147	1,100,000	66
	mS/m					5.94	440.00	14.7	110,000.0	15	110,000	6.6
	mS/cm	0.0594	4.4000	0.147	1,100.000	0.15	1,100.00	0.1	1,100.0	0	1,100	0.066
	S/m	0.0147	110.0000	0.015	110.000	0.01	110.00	0.0	110.0			0.0066
NL	µS/cm							245.0	8,166.7	817	6,125,000	353
	mS/m					24.50	816.67	81.7	612,500.0	82	612,500	35.3
	mS/cm	0.2450	8.1667	0.817	6,125.000	0.82	6,125.00	0.8	6,125.0	1	6,125	0.353
	S/m	0.0447	9.8000	0.082	612.500	0.08	612.50	0.1	612.5	0	613	0.0353
TF	µS/cm							245.0	8,166.7	817	6,125,000	347
	mS/m					24.50	816.67	81.7	612,500.0	82	612,500	34.7
	mS/cm	0.2450	8.1667	0.817	6,125.000	0.82	6,125.00	0.8	6,125.0	1	6,125	0.347
	S/m	0.0447	9.8000	0.082	612.500	0.08	612.50	0.1	612.5	0	613	0.0347
EP307B, EP307G, PN, PX	µS/cm							245.0	8,166.7	817	6,125,000	368
	mS/m					24.50	816.67	81.7	612,500.0	82	612,500	36.8
	mS/cm	0.2450	8.1667	0.817	6,125.000	0.82	6,125.00	0.8	6,125.0	1	6,125	0.368
	S/m	0.0447	9.8000	0.082	612.500	0.08	612.50	0.1	612.5	0	613	0.0368
HP, PP, PT, SP	µS/cm							215.0	7,166.7	717	5,375,000	323
	mS/m					21.50	716.67	71.7	537,500.0	72	537,500	32.3
	mS/cm	0.2150	7.1667	0.717	5,375.000	0.72	5,375.00	0.7	5,375.0	1	5,375	0.323
	S/m	0.0392	8.6000	0.072	537.500	0.07	537.50	0.1	537.5	0	538	0.0323
LB, UT	µS/m									1,700	56,667	2600
	µS/cm					17.00	566.67	56.7	425,000.0	57	425,000	26
	mS/m			1.700	56.667	5.67	42,500.00	5.7	42,500.0	6	42,500	2.6
	mS/cm	0.0310	6.8000	0.057	425.000	0.06	425.00	0.1	425.0	0	425	0.026
	S/m	0.0057	42.5000	0.006	42.500	0.01	42.50	0.0	42.5			0.0026

a. If Concentration or Custom units are selected, ranges correspond to selected Base Units.

b. Maximum allowable output setting is equivalent to display format.

c. Measurements are possible outside the low and high limits, but with reduced accuracy.

871FT Sensor Types

Table 15. 871FT Ranges and Minimum Allowable Output Span for Selected Sensors, Units, and Display Format

871FT English Sensor Type	Selected Units (a)	Selected Display Format (b) Low and High Limits of 1% Accuracy Range (c)										Min. Allow. Output Span
		0.9999		9.999		99.99		999.9		9,999		
		Low	High	Low	High	Low	High	Low	High	Low	High	
1C	µS/m											87000
	µS/cm									1,348	58,000	870
	mS/m							134.8	5,800.0	580	1,450,000	87
	mS/cm			1.348	58.000	5.80	14,500.00	5.8	14,500.0	6	14,500	0.87
	S/m	0.1348	5.8000	0.580	1,450.000	0.58	1,450.00	0.6	1,450.0	1	1,450	0.087
1D	µS/m											31100
	µS/cm							295.7	6,900.0	2,070	5,175,000	311
	mS/m					29.57	690.00	207.0	517,500.0	207	517,500	31.1
	mS/cm	0.2957	6.9000	2.070	5,175.000	2.07	5,175.00	2.1	5,175.0	2	5,175	0.311
	S/m	0.0782	8.2800	0.207	517.500	0.21	517.50	0.2	517.5	0	518	0.0311
1E	µS/m											20000
	µS/cm							191.4	4,466.7	1,340	3,350,000	200
	mS/m					19.14	446.67	134.0	335,000.0	134	335,000	20
	mS/cm	0.1914	4.4667	1.340	3,350.000	1.34	3,350.00	1.3	3,350.0	1	3,350	0.2
	S/m	0.0506	5.3600	0.134	335.000	0.13	335.00	0.1	335.0			0.02
1F	µS/m											8300
	µS/cm							130.1	5,600.0	560	1,400,000	83
	mS/m					13.01	560.00	56.0	140,000.0	56	140,000	8.3
	mS/cm	0.1301	5.6000	0.560	1,400.000	0.56	1,400.00	0.6	1,400.0	1	1,400	0.083
	S/m	0.0560	140.0000	0.056	140.000	0.06	140.00	0.1	140.0			0.0083
1G	µS/m									4,429	103,333	4700
	µS/cm					44.29	1,033.33	72.0	3,100.0	310	775,000	47
	mS/m			4.429	103.333	7.20	310.00	31.0	77,500.0	31	77,500	4.7
	mS/cm	0.0720	3.1000	0.310	775.000	0.31	775.00	0.3	775.0	0	775	0.047
	S/m	0.0310	77.5000	0.031	77.500	0.03	77.50	0.0	77.5			0.0047
1H	µS/m									2,714	63,333	2800
	µS/cm					27.14	633.33	190.0	475,000.0	190	475,000	28
	mS/m			2.714	63.333	19.00	47,500.00	19.0	47,500.0	19	47,500	2.8
	mS/cm	0.0718	7.6000	0.190	475.000	0.19	475.00	0.2	475.0	0	475	0.028
	S/m	0.0190	47.5000	0.019	47.500	0.02	47.50	0.0	47.5			0.0028
1J	µS/m									2,143	50,000	1600
	µS/cm					21.43	500.00	150.0	375,000.0	150	375,000	16
	mS/m			2.143	50.000	15.00	37,500.00	15.0	37,500.0	15	37,500	1.6
	mS/cm	0.0567	6.0000	0.150	375.000	0.15	375.00	0.2	375.0			0.016
	S/m	0.0150	37.5000	0.015	37.500	0.02	37.50					0.0016

Table 15. 871FT Ranges and Minimum Allowable Output Span for Selected Sensors,
Units, and Display Format (Continued)

871FT English Sensor Type	Selected Units (a)	Selected Display Format (b) Low and High Limits of 1% Accuracy Range (c)										Min. Allow. Output Span
		0.9999		9.999		99.99		999.9		9,999		
		Low	High	Low	High	Low	High	Low	High	Low	High	
2C	µS/m											34000
	µS/cm							324.3	7,566.7	2,270	5,675,000	340
	mS/m					32.43	756.67	227.0	567,500.0	227	567,500	34
	mS/cm	0.3243	7.5667	2.270	5,675.000	2.27	5,675.00	2.3	5,675.0	2	5,675	0.34
	S/m	0.0858	9.0800	0.227	567.500	0.23	567.50	0.2	567.5	0	568	0.034
2D	µS/m											12100
	µS/cm							188.2	8,100.0	810	2,025,000	121
	mS/m					18.82	810.00	81.0	202,500.0	81	202,500	12.1
	mS/cm	0.1882	8.1000	0.810	2,025.000	0.81	2,025.00	0.8	2,025.0	1	2,025	0.121
	S/m	0.0306	3.2400	0.081	202.500	0.08	202.50	0.1	202.5			0.0121
2E	µS/m											7800
	µS/cm							120.8	5,200.0	520	1,300,000	78
	mS/m					12.08	520.00	52.0	130,000.0	52	130,000	7.8
	mS/cm	0.1208	5.2000	0.520	1,300.000	0.52	1,300.00	0.5	1,300.0	1	1,300	0.078
	S/m	0.0520	130.0000	0.052	130.000	0.05	130.00	0.1	130.0			0.0078
2F	µS/m									3,143	73,333	3300
	µS/cm					31.43	733.33	220.0	550,000.0	220	550,000	33
	mS/m			3.143	73.333	22.00	55,000.00	22.0	55,000.0	22	55,000	3.3
	mS/cm	0.0832	8.8000	0.220	550.000	0.22	550.00	0.2	550.0	0	550	0.033
	S/m	0.0220	55.0000	0.022	55.000	0.02	55.00	0.0	55.0			0.0033
2G	µS/m									1,714	40,000	1800
	µS/cm					17.14	400.00	120.0	300,000.0	120	300,000	18
	mS/m			1.714	40.000	12.00	30,000.00	12.0	30,000.0	12	30,000	1.8
	mS/cm	0.0454	4.8000	0.120	300.000	0.12	300.00	0.1	300.0			0.018
	S/m	0.0120	30.0000	0.012	30.000	0.01	30.00					0.0018
2H	µS/m									1,627	70,000	1100
	µS/cm					16.27	700.00	70.0	175,000.0	70	175,000	11
	mS/m			1.627	70.000	7.00	17,500.00	7.0	17,500.0	7	17,500	1.1
	mS/cm	0.0700	175.0000	0.070	175.000	0.07	175.00	0.1	175.0			0.011
	S/m	0.0070	17.5000	0.007	17.500	0.01	17.50					0.0011
2J	µS/m							571.4	13,333.3	929	40,000	600
	µS/cm			5.714	133.333	9.29	400.00	40.0	100,000.0	40	100,000	6
	mS/m	0.5714	13.3333	0.929	40.000	4.00	10,000.00	4.0	10,000.0	4	10,000	0.6
	mS/cm	0.0400	100.0000	0.040	100.000	0.04	100.00	0.0	100.0			0.006
	S/m	0.0040	10.0000	0.004	10.000	0.00	10.00					0.0006
3C	µS/m											45300
	µS/cm							431.4	10,066.7	702	30,200	453
	mS/m					43.14	1,006.67	70.2	3,020.0	302	755,000	45.3
	mS/cm	0.4314	10.0667	0.702	30.200	3.02	7,550.00	3.0	7,550.0	3	7,550	0.453
	S/m	0.0702	3.0200	0.302	755.000	0.30	755.00	0.3	755.0	0	755	0.0453

Table 15. 871FT Ranges and Minimum Allowable Output Span for Selected Sensors, Units, and Display Format (Continued)

871FT English Sensor Type	Selected Units (a)	Selected Display Format (b) Low and High Limits of 1% Accuracy Range (c)										Min. Allow. Output Span
		0.9999		9.999		99.99		999.9		9,999		
		Low	High	Low	High	Low	High	Low	High	Low	High	
3E	µS/m											15900
	µS/cm							151.4	3,533.3	1,060	2,650,000	159
	mS/m					15.14	353.33	106.0	265,000.0	106	265,000	15.9
	mS/cm	0.1514	3.5333	1.060	2,650.000	1.06	2,650.00	1.1	2,650.0	1	2,650	0.159
	S/m	0.0401	4.2400	0.106	265.000	0.11	265.00	0.1	265.0			0.0159
3F, 3G	µS/m											7300
	µS/cm							113.9	4,900.0	490	1,225,000	73
	mS/m					11.39	490.00	49.0	122,500.0	49	122,500	7.3
	mS/cm	0.1139	4.9000	0.490	1,225.000	0.49	1,225.00	0.5	1,225.0	0	1,225	0.073
	S/m	0.0490	122.5000	0.049	122.500	0.05	122.50	0.0	122.5			0.0073
3H	µS/m									3,571	83,333	3800
	µS/cm					35.71	833.33	250.0	625,000.0	250	625,000	38
	mS/m			3.571	83.333	25.00	62,500.00	25.0	62,500.0	25	62,500	3.8
	mS/cm	0.0945	10.0000	0.250	625.000	0.25	625.00	0.3	625.0	0	625	0.038
	S/m	0.0250	62.5000	0.025	62.500	0.03	62.50	0.0	62.5			0.0038
3J	µS/m									2,143	50,000	2300
	µS/cm					21.43	500.00	150.0	375,000.0	150	375,000	23
	mS/m			2.143	50.000	15.00	37,500.00	15.0	37,500.0	15	37,500	2.3
	mS/cm	0.0567	6.0000	0.150	375.000	0.15	375.00	0.2	375.0			0.023
	S/m	0.0150	37.5000	0.015	37.500	0.02	37.50					0.0023
4C	µS/m											8900
	µS/cm							137.1	5,900.0	590	1,475,000	89
	mS/m					13.71	590.00	59.0	147,500.0	59	147,500	8.9
	mS/cm	0.1371	5.9000	0.590	1,475.000	0.59	1,475.00	0.6	1,475.0	1	1,475	0.089
	S/m	0.0590	147.5000	0.059	147.500	0.06	147.50	0.1	147.5			0.0089
4E	µS/m									3,000	70,000	3100
	µS/cm					30.00	700.00	210.0	525,000.0	210	525,000	31
	mS/m			3.000	70.000	21.00	52,500.00	21.0	52,500.0	21	52,500	3.1
	mS/cm	0.0794	8.4000	0.210	525.000	0.21	525.00	0.2	525.0	0	525	0.031
	S/m	0.0210	52.5000	0.021	52.500	0.02	52.50	0.0	52.5			0.0031
4F, 4G	µS/m									1,286	30,000	1400
	µS/cm					12.86	300.00	90.0	225,000.0	90	225,000	14
	mS/m			1.286	30.000	9.00	22,500.00	9.0	22,500.0	9	22,500	1.4
	mS/cm	0.0340	3.6000	0.090	225.000	0.09	225.00	0.1	225.0			0.014
	S/m	0.0090	22.5000	0.009	22.500	0.01	22.50					0.0014
4H	µS/m									1,162	50,000	700
	µS/cm					11.62	500.00	50.0	125,000.0	50	125,000	7
	mS/m			1.162	50.000	5.00	12,500.00	5.0	12,500.0	5	12,500	0.7
	mS/cm	0.0500	125.0000	0.050	125.000	0.05	125.00	0.1	125.0			0.007
	S/m	0.0050	12.5000	0.005	12.500	0.01	12.50					0.0007

Table 15. 871FT Ranges and Minimum Allowable Output Span for Selected Sensors,
Units, and Display Format (Continued)

871FT English Sensor Type	Selected Units (a)	Selected Display Format (b) Low and High Limits of 1% Accuracy Range (c)										Min. Allow. Output Span
		0.9999		9.999		99.99		999.9		9,999		
		Low	High	Low	High	Low	High	Low	High	Low	High	
4J	µS/m							428.6	10,000.0	697	30,000	400
	µS/cm			4.286	100.000	6.97	300.00	30.0	75,000.0	30	75,000	4
	mS/m	0.4286	10.0000	0.697	30.000	3.00	7,500.00	3.0	7,500.0	3	7,500	0.4
	mS/cm	0.0300	75.0000	0.030	75.000	0.03	75.00	0.0	75.0			0.004
	S/m	0.0030	7.5000	0.003	7.500	0.00	7.50					0.0004

a. If Concentration or Custom units are selected, ranges correspond to selected Base Units.
b. Maximum allowable output setting is equivalent to display format.
c. Measurements are possible outside the low and high limits, but with reduced accuracy.

FT10 Sensor Types

Table 16. FT10 Ranges and Minimum Allowable Output Span for Selected Sensor,
Units, and Display Format

FT10 Sensor Type	Selected Units (a)	Selected Display Format (b) Low and High Limits of 1% Accuracy Range (c)										Minimum Allowable Output Span
		0.9999		9.999		99.99		999.9		9,999		
		Low	High	Low	High	Low	High	Low	High	Low	High	
FT10-08	µS/cm									742	54,900	824
	mS/m							74.2	5,490.0	183	1,372,500	82.4
	mS/cm			0.742	54.900	1.83	13,725.00	1.8	13,725.0	2	13,725	0.824
	S/m	0.0742	5.4900	0.183	1,372.500	0.18	1,372.50	0.2	1,372.5	0	1,373	0.0824
FT10-12	µS/cm							154.0	5,133.3	513	3,850,000	231
	mS/m					15.40	513.33	51.3	385,000.0	51	385,000	23.1
	mS/cm	0.1540	5.1333	0.513	3,850.000	0.51	3,850.00	0.5	3,850.0	1	3,850	0.231
	S/m	0.0281	6.1600	0.051	385.000	0.05	385.00	0.1	385.0			0.0231
FT10-16	µS/cm							121.0	4,033.3	403	3,025,000	182
	mS/m					12.10	403.33	40.3	302,500.0	40	302,500	18.2
	mS/cm	0.1210	4.0333	0.403	3,025.000	0.40	3,025.00	0.4	3,025.0	0	3,025	0.182
	S/m	0.0221	4.8400	0.040	302.500	0.04	302.50	0.0	302.5			0.0182

a. If Concentration or Custom units are selected, ranges correspond to selected Base Units.
b. Maximum allowable output setting is equivalent to display format.
c. Measurements are possible outside the low and high limits, but with reduced accuracy.

Calculating Resistance Values

The **Manual**/Bench calibration type, in particular, uses loops of wire and a decade resistance box, a calibration plug, or calibration cable and a decade resistance box to present a known resistance to the transmitter. Before performing this type of calibration, you must calculate resistances based on the conductivity calibration values chosen in the previous section.

Electrodeless conductivity cells have a property known as the Geometric Cell Factor which relates the absolute conductance (or resistance) in the cell to the conductivity (specific conductance) of standard solutions. The Cell Factor is necessary for calculation of resistance values that correspond to the conductivity calibration values selected above. Table 17 lists the Geometric Cell Factors for Foxboro cells.

The apparent conductivity corresponding to a given resistance also depends on the number of times the wire is looped through the sensor (number of turns). To avoid using very low resistance values, where wire and contact resistance might cause errors, it may be necessary to use more than one loop. As a rule of thumb, it is recommended that resistances less than 200 ohms be avoided.

Table 17. Cell Factors

871EC Sensor		871FT English Sensor		871FT Metric Sensor		FT10 Sensors		Other Sensors	
Sensor Type	Geometric Cell Factor	Sensor Type	Geometric Cell Factor	Sensor Type	Geometric Cell Factor	Sensor Type	Geometric Cell Factor	Sensor Type	Geometric Cell Factor
-AB	0.588	-1C	11.60	-1C	9.54	-08	38.68	EP307B	2.49
-BW	0.873	-2C	11.60	-2C	9.54	-12	11.71	EP307G	2.49
-EV	0.45	-1D	4.14	-1D	4.61	-16	8.08	EP307B_T	2.84
-HP	2.15	-2D	4.14	-2D	4.61				
-LB	0.873	-1E	2.67	-1E	3.05				
-NL	2.35	-2E	2.67	-2E	3.05				
-PN	2.45	-1F	1.11	-1F	1.14				
-PX	2.45	-2F	1.11	-2F	1.14				
-RE	0.873	-1G	0.62	-1G	0.67				
-SP	2.15	-2G	0.62	-2G	0.67				
-TF	2.31	-1H	0.38	-2H	0.27				
-UT	0.873	-2H	0.38	-2H	0.27				
PP	2.185	-1J	0.21	-3E	0.80				
PT	2.185	-2J	0.21	-4E	0.80				
		-3C	3.02	-3F	0.62				
		-4C	3.02	-4F	0.62				
		-3E	1.06	-3G	0.44				
		-4E	1.06	-4G	0.44				
		-3F	0.49	-3H	0.19				
		-4F	0.49	-4H	0.19				
		-3G	0.49	-3J	0.11				
		-4G	0.49	-4J	0.11				
		-3H	0.25						
		-4H	0.25						
		-3J	0.15						
		-4J	0.15						

The following equation is used to calculate resistance:

$$R = \frac{1000 \times Cf \times n^2}{C \, \text{(mS/cm)}}$$

Where:

♦ R is the resistance in ohms (Ω)

♦ Cf is the sensor's cell factor in cm^{-1} (see Table 17)

♦ n is the number of times the wire will be looped through the sensor

♦ C is the conductivity value in mS/cm

For example, if a conductivity calibration value of 20 mS/cm for an 871EC-SP sensor is desired, the following calculation applies for 1 loop of wire:

$$R = \frac{1000 \times 2.15 \times 1^2}{20} = 107.5 \, \Omega$$

Since 107.5 Ω is less than the "rule-of-thumb" lowest resistance, multiple loops should be considered. For example, with 3 loops:

$$R = \frac{1000 \times 2.15 \times 3^2}{20} = 967.5 \, \Omega$$

With 3 loops, a resistance value of 967.5 Ω is obtained, well above the rule-of-thumb minimum.

> **— NOTE**
>
> When using an 871FT sensor with a Foxboro Calibration Cable, the date of manufacture must be taken into account, since some models contain multiple internal loops. See "Foxboro Calibration Cable with Decade Resistance Box" on page 83 below for details.

Measurement Calibration Examples

Example 1. 2-Point/Manual/Solution Calibration with an 871EC SP Sensor

This example describes a 2-point, **Manual**/Solution calibration of an 871EC SP sensor with the relevant options selected in the table below.

Options	Selections
Sensor Type	**871EC SP**
Number of Points (**1** or **2**)	**2**
Standard Entry (**Process** or **Manual**)	**Manual**
Value Entry (Solution or Bench)	**Solution**
Meas Units	**%**
Base Display Scale	**999.9 mS/cm**
Chemical Composition	**NaOH**
Conc Range	**25°C Ref**
Base Units	**mS/cm**

Since the 2-point calibration option is selected along with **Manual** and **Solution**, and concentration units have been chosen for display, the following must be assumed:

♦ The conductivity range corresponding to the expected concentration range must be known (refer to Table 8).

♦ Standard solutions are available in the conductivity range of interest and the conductivity values are known throughout the temperature range expected during calibration.

♦ It is feasible to remove the sensor from the process for insertion into calibration vessels.

The next step is to determine the desired calibration points. The range from Table 14 on page 90 for the 871EC SP sensor with a Base Display Scale of 999.9 mS/cm is 0.7 to 5,375 mS/cm. This is appropriate as it covers the conductivity range for NaOH at 25$^°$C reference temperature from Table 8 on page 53 of 0 to 420 mS/cm. Let's assume the concentration of interest for the application is covered by a 10 to 100 mS/cm range and therefore these values would be desirable for calibration points 1 and 2. Commercially available potassium chloride conductivity standards are readily available with values of 12.9 and 111.9 mS/cm at 25$^°$C and conductivity tables covering all relevant temperatures are shipped with the standards. With these standards on hand, the calibration procedure can be implemented.

Procedure

1. Configure the transmitter in accordance with the table above and save settings.

2. Fill calibration vessels with the two standards. It is best to allow them to equilibrate to a stable temperature that is not expected to vary much over the few minutes it takes to perform a calibration. Remove the 871EC SP sensor from the process, rinse it, dry it, and place it in the 12.9 mS/cm solution.

─── **NOTE** ───

The calibration vessel should be large enough for the sensor to be suspended at least 1.5 in (4 cm) from any surface including that of the liquid.
──

3. Enter the calibration mode:

   a. Press the **FUNCTION** key and then the **CAL** key.

   b. At the prompt, type the passcode and press **ENTER**.

   c. If desired, enter information in the **Calibrated By**, **Calibration Day**, **Calibration Month**, and **Calibration Year** fields. Recording this information is not mandatory, but doing so will allow you to keep track of when the instrument was last calibrated and who performed the calibration.

   d. Select **Calibrate** and press **ENTER**.

   e. Select the **Measurement** calibration type and press **ENTER**.

4. At the **Points** prompt, enter **2**.

5. At the **Standard** prompt, select **Manual**.

6. At the **Apply First Cal Input** prompt, place the sensor in the 12.9 mS/cm solution. Then, press **ENTER**.

7. The pre-calibration absolute conductivity value and current temperature are temporarily displayed while the reading is stabilizing. *Record the solution temperature and look up the absolute conductivity value for the first solution at that temperature.*

8. At the **Known** prompt, enter the known absolute conductivity value at the actual temperature and press **ENTER**.

9. Rinse and dry the sensor, then put it in the 111.9 mS/cm solution.

10. At the **Apply Second Cal Input** prompt, press **ENTER**.

11. The pre-calibration absolute conductivity value and current temperature are temporarily displayed while the reading is stabilizing. *Record the solution temperature and look up the absolute conductivity value for the second solution at that temperature.*

12. At the **Known** prompt, enter the *known absolute conductivity value at the actual temperature* and press **ENTER**.

13. When calibration is done, the display reads **Calibration Complete**. Press **ENTER**.

14. Press the **FUNCTION** key and **SAVE/EXIT** key to save your calibration.

Example 2. 1-Point/Process/Solution/Concentration Calibration with an 871EC SP Sensor

This example describes a 1-point, **Process/Solution** calibration of an 871EC SP sensor with the relevant options selected in the table below.

Options	Selections
Sensor Type	**871EC SP**
Number of Points (**1** or **2**)	**1**
Standard Entry (**Process** or **Manual**)	**Process**
Value Entry (Solution or Bench)	**Solution**
Meas Units	**%**
Base Display Scale	**999.9 mS/cm**
Chemical Composition	**NaOH**
Conc Range	**25°C Ref**
Base Units	**mS/cm**

This example follows logically from Example 1. Having performed a 2-point solution calibration on the loop with the 871EC SP sensor, one could imagine that the simpler, 1-point process calibration might be desirable to maintain the loop. Also, we can assume that the hypothetical user wishes to leave the sensor installed in the process, and that an independent means is available to determine the concentration of NaOH in the process at the time of calibration.

Procedure

1. Enter the Calibration mode:

   a. Press the **FUNCTION** key and then the **CAL** key.

   b. At the prompt, type the passcode and press **ENTER**.

   c. If desired, enter information in the **Calibrated By**, **Calibration Day**, **Calibration Month**, and **Calibration Year** fields. Recording this information is not mandatory, but doing so will allow you to keep track of when the instrument was last calibrated and who performed the calibration.

   d. Select **Calibrate** and press **ENTER**.

   e. Select the **Measurement** calibration type and press **ENTER**.

2. At the **Points** prompt, enter **1**.

3. At the **Standard** prompt, select **Process**.

4. At the **Apply First Cal Input** prompt, press **ENTER**.

5. The pre-calibration concentration and temperature values are temporarily displayed while the reading is stabilizing.

6. At the **Known** prompt, enter the known NaOH concentration in the process and press **ENTER**.

7. When calibration is done, the display reads **Calibration Complete**. Press **ENTER**.

8. Press the **FUNCTION** key and **SAVE/EXIT** key to save your calibration.

Example 3. 2-Point/Manual/Bench Calibration with an 871EC SP Sensor

This example describes a **Manual/Bench** calibration of an 871EC SP sensor with the relevant options selected in the table below.

Options	Selections
Sensor Type	**871EC SP**
Number of Points (**1** or **2**)	**2**
Standard Entry (**Process** or **Manual**)	**Manual**
Value Entry (Solution or Bench)	**Bench**
Meas Units	**%**
Base Display Scale	**999.9 mS/cm**
Chemical Composition	**NaOH**
Conc Range	**25ºC Ref**
Base Units	**mS/cm**

This example again follows from Example 1. In this case however, a Bench calibration with fixed resistances will be carried out, employing a user-supplied wire and decade resistance box.

In this case, it is assumed that the lowest region of the measuring range is not the most important range, so the first calibration value will be obtained by suspending the sensor in air and defining the calibration value as 0.0 mS/cm. This is simpler and faster than using two fixed resistances. When the low range is very important, it is better to use two fixed resistances as in Example 4. The second, higher calibration value will be obtained with a fixed resistance.

Let's assume that the same higher conductivity calibration values as in Example 1 is desired: 100 mS/cm. First, let's use the resistance formula to calculate resistance based on a single loop of wire though the sensor bore.

Resistance formula:

$$R = \frac{1000 \times Cf \times n^2}{C}$$

For 100 mS/cm:

$$R = \frac{1000 \times 2.15 \times 1^2}{100} = 21.5 \ \Omega$$

This value is too low to satisfy our rule-of-thumb minimum of 200 Ω. In fact, it will have to be multiplied by almost 10 times to be above that level. So let's take a look at 4 turns of wire, which results in n^2 or a 16-fold multiplier.

For 100 mS/cm:

$$R = \frac{1000 \times 2.15 \times 4^2}{100} = 344 \ \Omega$$

This value is above 200 Ω, and we can proceed.

Procedure

1. Enter the Calibration mode:

    a. Press the **FUNCTION** key and then the **CAL** key.

    b. At the prompt, type the passcode and press **ENTER**.

    c. If desired, enter information in the **Calibrated By**, **Calibration Day**, **Calibration Month**, and **Calibration Year** fields. Recording this information is not mandatory, but doing so will allow you to keep track of when the instrument was last calibrated and who performed the calibration.

    d. Select **Calibrate** and press **ENTER**.

    e. Select the **Measurement** calibration type and press **ENTER**.

2. At the **Points** prompt, enter **2**.

3. At the **Standard** prompt, select **Manual**.

4. At the **Apply First Cal Input** prompt, rinse, dry, and suspend the sensor in air, at least 6 in (15 cm) from any objects, then press **ENTER**.

5. The pre-calibration absolute conductivity value and current temperature are temporarily displayed while the reading is stabilizing.

6. At the **Known** prompt, enter **0.0** mS/cm and press **ENTER**.

7. At the **Apply Second Cal Input** prompt, loop the wire 4 times through the sensor and connect to the decade resistance box. Adjust the box as close to 344 Ω as possible, then press **ENTER**.

8. The pre-calibration absolute conductivity value and current temperature are temporarily displayed while the reading is stabilizing.

9. At the **Known** prompt, enter **100.0** mS/cm and press **ENTER**.

10. When calibration is done, the display reads **Calibration Complete**. Press **ENTER**.

Example 4. 2-Point/Manual/Bench Calibration with an 871EC-LB Sensor

This example describes a 2-point **Manual/Bench** calibration of an 871EC-LB sensor with the relevant options selected in the table below.

Options	Selections
Sensor Type	**871EC LB**
Number of Points (**1** or **2**)	**2**
Standard Entry (**Process** or **Manual**)	**Manual**
Value Entry (Solution or Bench)	**Bench**
Meas Units	**mS/cm**
Base Display Scale	**999.9 µS/cm**
Temp Comp	**Dilute NaCl**

As in Example 3, a Bench calibration employing a user-supplied wire and decade resistance box will be carried out. In this example, however, let's assume that the lower region of the measuring range is very important. So, rather than suspending the sensor in air, a fixed resistance will be used for the first, lower calibration point as well as for the second point. Resistance values corresponding to the two desired conductivity calibration values will have to be calculated.

Let's choose 40 and 400 µS/cm (0.04 and 0.4 mS/cm) as the range of interest and calibrate at these values. Let's try the resistance formula to calculate resistances based on a single loop of wire though the sensor bore.

Resistance formula:

$$R = \frac{1000 \times Cf \times n^2}{C}$$

For 0.04 mS/cm:

$$R = \frac{1000 \times 0.873 \times 1^2}{0.04} = 21825 \ \Omega$$

For 0.4 mS/cm:

$$R = \frac{1000 \times 0.873 \times 1^2}{0.4} = 2182.5 \ \Omega$$

These are satisfactory resistance values and we can proceed.

Procedure

1. Enter the Calibration mode:

    a. Press the **FUNCTION** key and then the **CAL** key.

    b. At the prompt, type the passcode and press **ENTER**.

c. If desired, enter information in the **Calibrated By**, **Calibration Day**, **Calibration Month**, and **Calibration Year** fields. Recording this information is not mandatory, but doing so will allow you to keep track of when the instrument was last calibrated and who performed the calibration.

d. Select **Calibrate** and press **ENTER**.

e. Select the **Measurement** calibration type and press **ENTER**.

2. At the **Points** prompt, enter **2**.

3. At the **Standard** prompt, select **Manual**.

4. At the **Apply First Cal Input** prompt, set the decade resistance box as close to 21825 Ω as possible, connect the wire once through the sensor bore, then press **ENTER**.

5. The pre-calibration absolute conductivity value and current temperature are temporarily displayed while the reading is stabilizing.

6. At the **Known** prompt, enter **40.0** μS/cm and press **ENTER**.

7. At the **Apply Second Cal Input** prompt, change the decade resistance box setting to as close to 2182.5 Ω as possible, connect the wire once through the sensor bore, then press **ENTER**.

8. The pre-calibration absolute conductivity value and current temperature are temporarily displayed while the reading is stabilizing.

9. At the **Known** prompt, enter **400.0** μS/cm and press **ENTER**.

10. When calibration is done, the display reads **Calibration Complete**. Press **ENTER**.

Example 5: 2-Point/Manual/Bench Calibration with an 871FT-3G Sensor with Foxboro Calibration Cable and Foxboro Calibration Plug

This example describes a 2-point **Manual/Bench** calibration of an 871FT-3G###R. This is a 2-inch bore industrial sensor with a 1000-Ω RTD. In this example, resistance calculations for the use of Foxboro Calibration Cable with decade resistance box are carried out, but it is found that the Foxboro Calibration Plug is a better approach.

Options	Selections
Sensor Type	**871EC-3G###R**
Number of Points (**1** or **2**)	**2**
Standard Entry (**Process** or **Manual**)	**Manual**
Value Entry (Solution or Bench)	**Bench**
Meas Units	**%**
Base Display Scale	**999.9 mS/cm**
Chemical Composition	**Sulfuric Acid**
Conc Range	**25°C Ref**
Base Units	**mS/cm**

As in Example 3, where a user-supplied wire was used, it will be necessary to calculate resistance values corresponding to the desired conductivity points and these must be selected first.

The conductivity range for an 871FT-3G with a Base Display Scale of 999.9 mS/cm from Table 15 is 0.5 to 1,225 mS/cm. This is appropriate for Sulfuric Acid with Tref = 25°C, which from Table 8 on page 53 covers a conductivity range of 0 to 800 mS/cm. Let's assume for this application that the measurement range of interest is 100 to 500 mS/cm and these are the desired calibration points for which resistances must be calculated.

Model 871FT sensors have connection ports that serve to connect a calibration cable, calibration plug, or RTD. The contacts for the calibration cable or plug connect to either 1 or 5 turns of calibration wire through the bore, depending on the date of manufacture of the sensor. The date of manufacture is determined from the last four digits of the Origin Date Code found on the sensor data plate. A code of 2B0149 means the sensor was manufactured in week 49 of 2001. Sensors with Origin Date Codes of 2B9710 or later have 5 wire loops through the bore, so n = 5 in the resistance equation. For sensors manufactured earlier than 2B1049, n = 1.

Let's assume the sensor in our example was manufactured after 2B9710 and therefore n = 5.

Resistance formula:

$$R = \frac{1000 \times Cf \times n^2}{C}$$

For 100 mS/cm:

$$R = \frac{1000 \times 0.49 \times 5^2}{100} = 122.5 \ \Omega$$

For 500 mS/cm:

$$R = \frac{1000 \times 0.49 \times 5^2}{500} = 24.5 \ \Omega$$

These values are too low to satisfy our rule-of-thumb minimum of 200 Ω for use with a user-supplied wire or Foxboro Calibration Cable. Also, since it is desired to use a Calibration Cable or Calibration Plug, there is no opportunity to increase the number of wire turns. In this case, the Foxboro Calibration Plug is the only option. With the Calibration Plug, resistances less than 10 ohms can be used without concerns about accuracy, as contact and wire resistances are not an issue and high-precision resistors are used.

Foxboro Calibration Plugs are made to order in accordance with customer specifications. The conductivity values desired and type of conductivity sensor are specified on the order and plugs labeled with the sensor type and conductivity calibration values are shipped directly to the user.

With the specified Calibration Plugs on hand, calibration can proceed.

Procedure

1. Flush the 871FT sensor with air or fluid having a conductivity of less than 100 µS/cm (microsiemens/cm). Enter the Calibration mode and at the prompts enter the name of the person doing the calibration and the calibration day, month, and year. At the **Calibrate** prompt, select **Measurement** and press **ENTER**.

2. At the **Points** prompt, enter **2**.

3. At the **Standard** prompt, select **Manual**.

4. At the **Apply First Cal Input** prompt, unplug the RTD from the RTD/Cable connection port on the sensor and connect the Calibration Plug labeled 100 mS/cm. Then press **ENTER**.

5. The pre-calibration absolute conductivity value and temperature[1] are temporarily displayed while the reading is stabilizing.

6. At the **Known** prompt, enter 100.0 mS/cm and press **ENTER**.

7. At the **Apply Second Cal Input** prompt, replace the 100 mS/cm Plug with the 500 mS/cm Plug. Then press **ENTER**.

8. The pre-calibration absolute conductivity value and temperature [1] are temporarily displayed while the reading is stabilizing.

9. At the **Known** prompt, enter 500.0 mS/cm and press **ENTER**.

10. When calibration is done, the display reads **Calibration Complete**. Press **ENTER**.

---

1. The temperature displayed will depend on the exact Calibration Plug ordered, but is irrelevant in Manual/Bench calibration.

Appendix B. Auto Calibration

Auto calibration is provided for advanced users with automated systems for cleaning and re-calibrating the probe. These systems require an external control system to orchestrate the process. The transmitter activates its output hold feature, and performs solution calibrations. Auto-service is initiated by the external control system. There is no scheduling nor time delays in the transmitter.

A typical calibration includes:

- ◆ Activate output hold
- ◆ Start solution calibration: low, providing known value
- ◆ Start solution calibration: high, providing known value
- ◆ Determine when calibration (low or high) is complete
- ◆ Release output hold

There are two HART hold commands:

- ◆ Activate Output Hold
- ◆ Release Output Hold

There are three HART auto-calibration commands:

- ◆ Start Calibration
- ◆ Check Calibration Status
- ◆ Finish Calibration

There are two commands used to save changes

- ◆ Write Entity Byte Base
- ◆ Read Entity Byte User Attributes

The following calibrations may be performed:

- ◆ 1- or 2-point manual measurement calibration
- ◆ 1- or 2-point process measurement calibration
- ◆ 1- or 2-point temperature calibration
- ◆ 2-point mA calibration

Calibration Parameters

Use the following values for:

Calibration Type (1 byte)

Measurement Calibration 1st point: 105

Measurement Calibration 2nd point: 106

Temperature 1st point: 107

Temperature 2nd Point: 108

mA Calibration 4 mA: 109

mA Calibration 20 mA: 110

Number of Calibration Points: 1, 2

Calibration Source

Manual: 2

Process: 3

Application to calibrate: 1

Calibrator's Initials: 6 characters

Calibration Date: Hart Date format (year, month, day + 1900)

Calibration Units:

degC: 4

degF: 3

mA: 2

%:   1

ppm: 11

ppb: 12

g/l: 23

oz/gal: 24

ppt : 25

none: 26

user: 27

Command Sequence

1. If explicit output hold is required, issue Activate Output Hold (0x92). Otherwise, automatic hold ensues.

2. Activate automatic system to provide calibration buffer to the sensor.

3. Send Start Cal (0x94) command.

4. Send Cal Status (0x95) command, read until measurement is stable.

5. Send Finish Cal (0x96) command.

6. Repeat steps 2 through 5 for each calibration point.

7. Save changes by writing to save changes and check changes entities.

    a. Write 1 to byte entity 11.

    b. Write 0 to byte entity 12.

    c.   Read entity 12 attributes (8F02000C).

    d.   Repeat steps b and c until entity goes invisible.

8.   Release any output hold (0x93).

Cmd 148 (0x94): Start Cal

(This command holds off QuickStart)

HART Command Type   : Device Specific

HART Versions   : 5 6 7

HART Operation Type   : COMMAND

Code Section

    Support In Boot   : False

    Support In Main   : True

    Support Function   : StartCal.

Request: 22 (0x16) bytes (plus preambles)

Size	Type	Fixed/Var	HART Ver #	Example	Description
1	byte	Fixed	567	0x82	Request Delimiter
5	byte	Var	567	0x??????????	Device Address
1	byte	Fixed	567	0x94	Command 148
1	byte	Fixed	567	0x0D(13d)	Data Length (not including checksum)
1	byte	Var	567	0x??	CalType
1	byte	Var	567	0x??	CalPoints
1	byte	Var	567	0x??	CalSource
1	byte	Var	567	0x??	AppIndex
3	date	Var	567	DDMMYY	CalDate
6	char	Var	567	xxxxxx	CalPerson
1	byte	Var	567	0x??	HART Checksum

Response: 24 (0x18) bytes (plus preambles)

Size	Type	Fixed/Var	HART Ver #	Example	Description
1	byte	Fixed	567	0x86	Response Delimiter
5	byte	Var	567	0x??????????	Device Address
1	byte	Fixed	567	0x94	Command 148
1	byte	Fixed	567	0x0F(15d)	Data Length (not including checksum)
1	byte	Var	567	0x00	HART Command Status
1	byte	Var	567	0x??	HART Device Status (Configuration Changed Flag set)
1	byte	Var	567	0x??	CalType
1	byte	Var	567	0x??	CalPoints
1	byte	Var	567	0x??	CalSource
1	byte	Var	567	0x??	AppIndex
3	date	Var	567	DDMMYY	CalDate
6	char	Var	567	xxxxxx	CalPerson
1	byte	Var	567	0x??	HART Checksum

Cmd 149 (0x95): Read Cal Status

(This command holds off QuickStart)

HART Command Type   : Device Specific

HART Versions   : 5 6 7

HART Operation Type   : COMMAND

Code Section

    Support In Boot   : False

    Support In Main   : True

    Support Function   : RdCalStatus.

Request: 10 (0x0A) bytes (plus preambles)

Size	Type	Fixed/Var	HART Ver #	Example	Description
1	byte	Fixed	567	0x82	Request Delimiter
5	byte	Var	567	0x??????????	Device Address
1	byte	Fixed	567	0x95	Command 149
1	byte	Fixed	567	0x01(1d)	Data Length (not including checksum)
1	byte	Var	567	0x??	CalType
1	byte	Var	567	0x??	HART Checksum

Response: 18 (0x12) bytes (plus preambles)

Size	Type	Fixed/Var	HART Ver #	Example	Description
1	byte	Fixed	567	0x86	Response Delimiter
5	byte	Var	567	0x??????????	Device Address
1	byte	Fixed	567	0x95	Command 149
1	byte	Fixed	567	0x09(9d)	Data Length (not including checksum)
1	byte	Var	567	0x00	HART Command Status
1	byte	Var	567	0x??	HART Device Status (Configuration Changed Flag set)
1	byte	Var	567	0x??	CalType
1	byte	Var	567	0x??	CalStable
1	byte	Var	567	0x??	CalUnits
4	real	Var	567	? 0.0	CalValue
1	byte	Var	567	0x??	HART Checksum

Cmd 150 (0x96): Finish Cal

(This command holds off QuickStart)

HART Command Type   : Device Specific

HART Versions   : 5 6 7

HART Operation Type   : COMMAND

Code Section

    Support In Boot   : False

    Support In Main   : True

    Support Function   : FinishCal.

Request: 15 (0x0F) bytes (plus preambles)

Size	Type	Fixed/Var	HART Ver #	Example	Description
1	byte	Fixed	567	0x82	Request Delimiter
5	byte	Var	567	0x??????????	Device Address
1	byte	Fixed	567	0x96	Command 150
1	byte	Fixed	567	0x06(6d)	Data Length (not including checksum)
1	byte	Var	567	0x??	CalType
1	byte	Var	567	0x??	CalUnits
4	real	Var	567	? 0.0	CalValue
1	byte	Var	567	0x??	HART Checksum

Response: 17 (0x11) bytes (plus preambles)

Size	Type	Fixed/Var	HART Ver #	Example	Description
1	byte	Fixed	567	0x86	Response Delimiter
5	byte	Var	567	0x??????????	Device Address
1	byte	Fixed	567	0x96	Command 150
1	byte	Fixed	567	0x08(8d)	Data Length (not including checksum)
1	byte	Var	567	0x00	HART Command Status
1	byte	Var	567	0x??	HART Device Status (Configuration Changed Flag set)
1	byte	Var	567	0x??	CalType
1	byte	Var	567	0x??	CalUnits
4	real	Var	567	? 0.0	CalValue
1	byte	Var	567	0x??	HART Checksum

Cmd 142 (0x8E): Write Entity Byte Base

(This command holds off QuickStart)

HART Command Type   : Device Specific

HART Versions   : 5 6 7

HART Operation Type   : WRITE

Code Section

    Support In Boot   : False

    Support In Main   : True

    Support Function   HARTE_BytWrBase.

Request: 12 (0x0C) bytes (plus preambles)

Size	Type	Fixed/Var	HART Ver #	Example	Description
1	byte	Fixed	567	0x82	Request Delimiter
5	byte	Var	567	0x??????????	Device Address
1	byte	Fixed	567	0x8E	Command 142
1	byte	Fixed	567	0x03(3d)	Data Length (not including checksum)
2	int	Var	567	0	EntityIndex
1	byte	Var	567	0x00	EntityValue
1	byte	Var	567	0x??	HART Checksum

Response: 15 (0x0F) bytes (plus preambles)

Size	Type	Fixed/Var	HART Ver #	Example	Description
1	byte	Fixed	567	0x86	Response Delimiter
5	byte	Var	567	0x??????????	Device Address
1	byte	Fixed	567	0x8E	Command 142
1	byte	Fixed	567	0x06(6d)	Data Length (not including checksum)
1	byte	Var	567	0x00	HART Command Status
1	byte	Var	567	0x??	HART Device Status (Configuration Changed Flag set)
2	int	Var	567	? 0	EntityIndex
1	byte	Var	567	0x??	EntityValue
1	byte	Var	567	0x??	Error
1	byte	Var	567	0x??	HART Checksum

Cmd 143 (0x8F): Read Entity Byte User Attributes

HART Command Type   : Device Specific

HART Versions   : 5 6 7

HART Operation Type   : READ

Code Section

    Support In Boot   : False

    Support In Main   : True

    Support Function   HARTE_BytRdUserAtt.

Request: 11 (0x0B) bytes (plus preambles)

Size	Type	Fixed/Var	HART Ver #	Example	Description
1	byte	Fixed	567	0x82	Request Delimiter
5	byte	Var	567	0x??????????	Device Address
1	byte	Fixed	567	0x8F	Command 143
1	byte	Fixed	567	0x02(2d)	Data Length (not including checksum)
2	int	Var	567	1	EntityIndex
1	byte	Var	567	0x??	HART Checksum

Response: 20 (0x14) bytes (plus preambles)

Size	Type	Fixed/Var	HART Ver #	Example	Description
1	byte	Fixed	567	0x86	Response Delimiter
5	byte	Var	567	0x??????????	Device Address
1	byte	Fixed	567	0x8F	Command 143
1	byte	Fixed	567	0x0B(11d)	Data Length (not including checksum)
1	byte	Var	567	0x00	HART Command Status
1	byte	Var	567	0x??	HART Device Status (Configuration Changed Flag set)
2	int	Var	567	? 0	EntityIndex
1	byte	Var	567	0x??	InVisibility = 0x80 bit
4	byte	Var	567	0x????????	PicksInVisible
1	byte	Var	567	0x??	Error
1	byte	Var	567	0x??	EntityValue
1	byte	Var	567	0x??	HART Checksum

Cmd 146 (0x92): Activate Output Hold

(This command holds off QuickStart)

HART Command Type   : Device Specific

HART Versions   : 5 6 7

HART Operation Type   : COMMAND

Code Section

Support In Boot   : False

Support In Main: True

Support Function   : ActivateOutputHold.

Request: 30 (0x1E) bytes (plus preambles)

Size	Type	Fixed/Var	HART Ver #	Example	Description
1	byte	Fixed	567	0x82	Request Delimiter
5	byte	Var	567	0x??????????	Device Address
1	byte	Fixed	567	0x92	Command 146
1	byte	Fixed	567	0x15(21d)	Data Length (not including checksum)
1	byte	Var	567	0x??	Hold Mode
4	real	Var	567	3.6	Hold mA
4	real	Var	567	7	Hold PV (a)
4	real	Var	567	25	Hold SV (a)
4	real	Var	567	0	Hold TV (a)
4	real	Var	567	109.73	Hold QV (a)
1	byte	Var	567	0x??	HART Checksum

a. PV, SV, TV, and QV must be presented in the base units used in the transmitter: Degrees Celsius, Ohms for RTD, kOhms for electrodes, mS/cm.

Response: 32 (0x20) bytes (plus preambles)

Size	Type	Fixed/Var	HART Ver #	Example	Description
1	byte	Fixed	567	0x86	Response Delimiter
5	byte	Var	567	0x??????????	Device Address
1	byte	Fixed	567	0x92	Command 146
1	byte	Fixed	567	0x17(23d)	Data Length (not including checksum)
1	byte	Var	567	0x00	HART Command Status
1	byte	Var	567	0x??	HART Device Status (Configuration Changed Flag set)
1	byte	Var	567	0x??	Hold Mode
4	real	Var	567	3.6	Hold mA
4	real	Var	567	7	Hold PV (a)
4	real	Var	567	25	Hold SV (a)
4	real	Var	567	0	Hold TV (a)
4	real	Var	567	109.73	Hold QV (a)
1	byte	Var	567	0x??	HART Checksum

a. PV, SV, TV, and QV must be presented in the base units used in the transmitter: Degrees Celsius, Ohms for RTD, kOhms for electrodes, mS/cm.

Possible HART Command Status errors returned:

(5) 0x05 Error   Too few data bytes received

Cmd 147 (0x93): Release Output Hold

HART Command Type   : Device Specific

HART Versions   : 5 6 7

HART Operation Type   : COMMAND

Code Section

    Support In Boot   : False

    Support In Main   : True

    Support Function   : ReleaseOutputHold.

Request: 9 (0x09) bytes (plus preambles)

Size	Type	Fixed/Var	HART Ver #	Example	Description
1	byte	Fixed	567	0x82	Request Delimiter
5	byte	Var	567	0x??????????	Device Address
1	byte	Fixed	567	0x93	Command 147
1	byte	Fixed	567	0x00(0d)	Data Length (not including checksum)
1	byte	Var	567	0x??	HART Checksum

Response: 11 (0x0B) bytes (plus preambles)

Size	Type	Fixed/Var	HART Ver #	Example	Description
1	byte	Fixed	567	0x86	Response Delimiter
5	byte	Var	567	0x??????????	Device Address
1	byte	Fixed	567	0x93	Command 147
1	byte	Fixed	567	0x02(2d)	Data Length (not including checksum)
1	byte	Var	567	0x00	HART Command Status
1	byte	Var	567	0x??	HART Device Status (Configuration Changed Flag set)
1	byte	Var	567	0x??	HART Checksum

Appendix C. Configuration Structure Diagrams

Figure 29. Configuration Top Level Structure

CONFIGURE

Sensor Type	→ A2
<Sensor> Type[a]	→ A2
Temp Type	→ A3
Number of Apps	→ A4
A1 Configuration[b]	
A2 Configuration[b]	
A3 Configuration[b]	
Meas Config[c]	→ A5
Temp Config[c]	→ A6
Temp Comp[c]	→ A7
Analog Out (PV)[c]	→ A8
AO Failsafe	→ A9
Meas Display[c]	→ A10
Run Applications[b]	→ A11
HART Digital	→ A12
Enable/Disable Diags	→ A13
Auto Hold	→ A14
Config Timeout	→ A15
Transmitter Tags	→ A16
Passcode Access	→ A17
Stability	→ A18
Restore Config	→ A19

(b)

(b)	
A# Name	
A# Meas Config	→ A5
A# Temp Config	→ A6
A# Temp Comp	→ A7
A# Analog Out (PV)	→ A8
A# Meas Display	→ A9

(a) This field displays 871EC Type, 871FT Type, or FT10 Type, depending on Sensor Type chosen in previous field.
(b) If Number of Apps = 2 or 3
(c) If Number of Apps = 1

— **NOTE** —————————————————

Before entering Configuration mode, you must first enter a proper passcode.
The factory default passcode is 0800.

Figure 30. Sensor Type Configuration Structure

A2 → **SENSOR TYPE**

SENSOR TYPE
871EC
871FT English
871FT Metric
EP307
FT10
Other

FT10

FT10 TYPE
FT10-08
FT10-12
FT10-16

871FT Metric

871FT TYPE
871FT-1C
871FT-2C
871FT-1D
871FT-2D
871FT-1E
871FT-2E
871FT-1F
871FT-2F
871FT-1G
871FT-2G
871FT-1H
871FT-2H
871FT-3E
871FT-4E
871FT-3F
871FT-4F
871FT-3G
871FT-4G
871FT-3H
871FT-4H
871FT-3J
871FT-4J

871FT English

871FT TYPE
871FT-1C
871FT-2C
871FT-1D
871FT-2D
871FT-1E
871FT-2E
871FT-1F
871FT-2F
871FT-1G
871FT-2G
871FT-1H
871FT-2H
871FT-1J
871FT-2J
871FT-3C
871FT-4C
871FT-3E
871FT-4E
871FT-3F
871FT-4F
871FT-3G
871FT-4G
871FT-3H
871FT-4H
871FT-3J
871FT-4J

871EC Type

871EC TYPE
SP
HP
LB
UT
RE
BW
TF
NL
EV
AB
PN
PX
PP
PT

Figure 31. Temperature Type Configuration Structure

A3	TEMP TYPE
	2-Wire Pt 100
	2-Wire Pt 1000
	3-Wire Pt 100
	3-Wire Pt 1000
	Mil RTD
	100K Thermistor
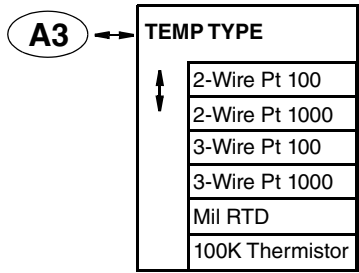
Figure 32. Number of Applications Configuration Structure

A4	Number of Apps
	1
	2
	3

Figure 33. Measurement Configuration Structure
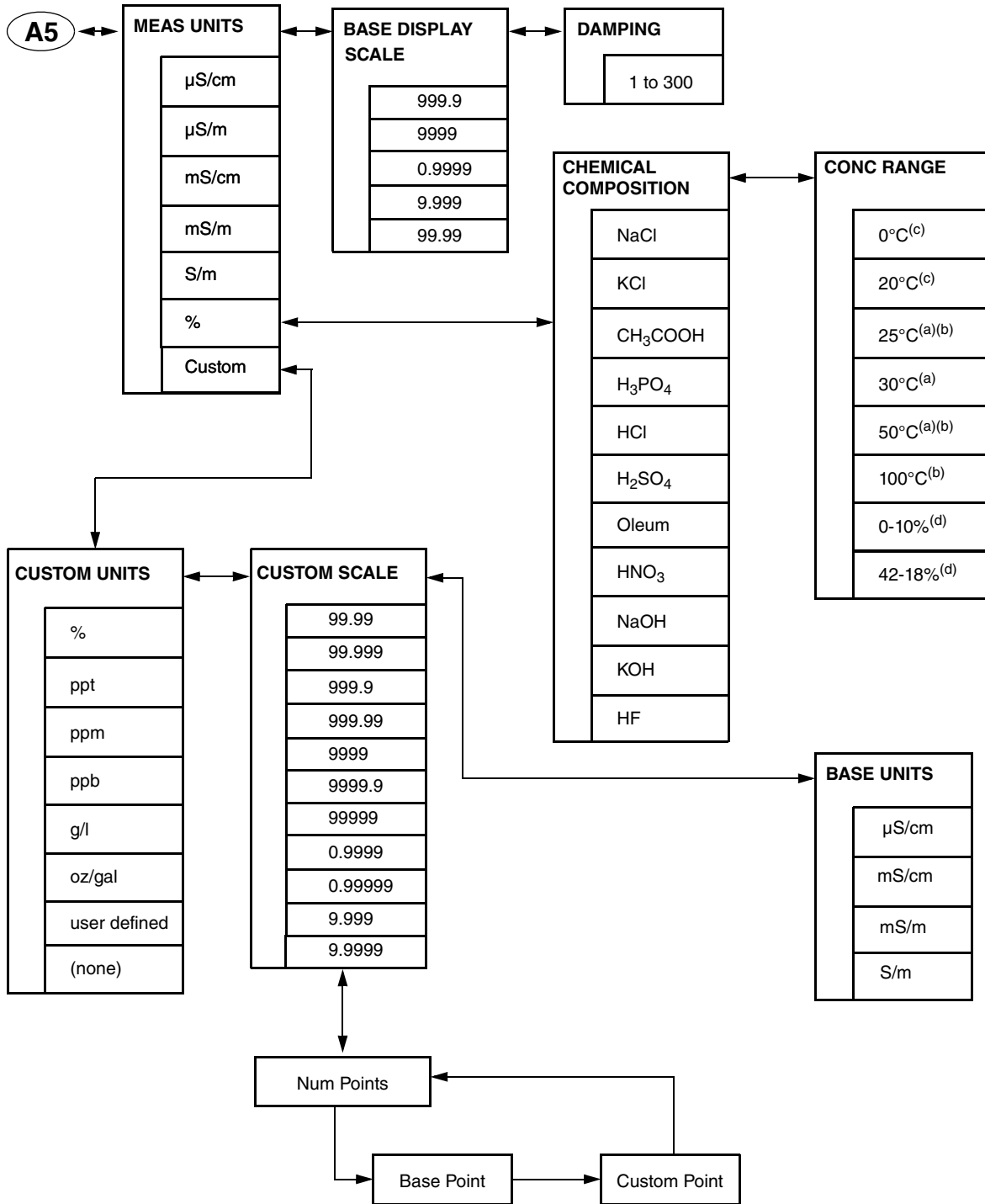
(a) If chemical composition selected is H_2SO_4 - 25 deg, 30 deg, 50 deg

(b) If chemical composition selected is NaOH - 25 deg, 50 deg, 100 deg

(c) If chemical composition selected is HF - 0 deg, 20 deg

(d) If chemical composition selected is Oleum

Figure 34. Temperature Configuration Structure

```
A6 ◄─► Temp Units
         ┌──────┐
         │  °C  │
         │  °F  │
         └──────┘

       Temp Mode
         ┌────────┐
         │  Auto  │──────────────────┐
         │ Manual │───────┐          │
         └────────┘       ▼          ▼
                    ┌────────────┐ ┌───────────┐
                    │ Manual Temp│ │ Fail Temp │
                    └────────────┘ └───────────┘
```
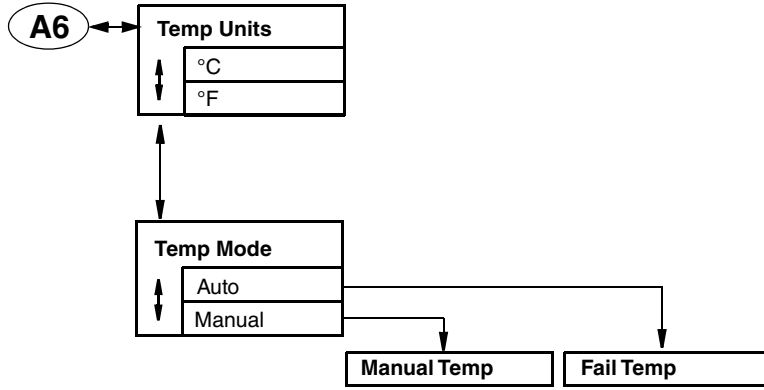
Figure 35. Temperature Compensation Structure

```
A7 ◄─► Temp Comp          ◄──────►        Reference Temperature
         ┌──────────────┐                    ┌─────────┐
         │   Absolute   │                    │   0°C   │
         │  Dilute NaCl │                    │  20°C   │
         │     NaCl     │                    │  25°C   │
         │  Sea Water   │                    │  30°C   │
         │     KCl      │                    │  50°C   │
         │   CH₃COOH    │                    │  100°C  │
         │    H₃PO₄     │                    └─────────┘
         │     HCl      │
         │    H₂SO₄     │──► Ref Temp (25°C, 30°C, or 50°C)
         │    Oleum     │
         │    HNO₃      │
         │    NaOH      │──► Ref Temp (25°C, 50°C, or 100°C)
         │     KOH      │
         │      HF      │──► Ref Temp (0°C or 20°C)
         │ Green Liquor │
         │ Black Liquor │
         │   Linear     │
         │   Custom     │──► ┌──────────┐ ◄─► ┌────────────┐
         └──────────────┘    │ Ref Temp │     │ Num Points │◄──┐
                             └──────────┘     └────────────┘   │
                                                               │
                             ┌────────────┐ ◄─► ┌────────────┐ │
                          ┌─►│ Temp/Pnt n │     │ Value/Pnt n│─┘
                          │  └────────────┘     └────────────┘
                          └────── Repeat for each point ───────┘
```
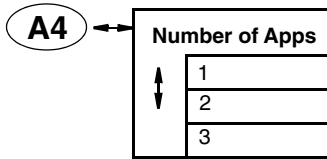
Reference Temperature options: $0°C$, $20°C$, $25°C$, $30°C$, $50°C$, $100°C$

Temp Comp options: Absolute, Dilute NaCl, NaCl, Sea Water, KCl, CH_3COOH, H_3PO_4, HCl, H_2SO_4, Oleum, HNO_3, NaOH, KOH, HF, Green Liquor, Black Liquor, Linear, Custom

H_2SO_4 ──► Ref Temp (25°C, 30°C, or 50°C)
NaOH ──► Ref Temp (25°C, 50°C, or 100°C)
HF ──► Ref Temp (0°C or 20°C)

Figure 36. Analog Output Structure

AO Source
- Measurement
- Temperature
- Absolute
- Concentration[a]
- Cell Resistance
- ATC Resistance

Low Value[b]

Upper Value[b]

HART SV

HART TV

HART QV

If Number of Apps is greater than 1

A# AO Endpoints[c]
- A# mA High Value[c]
- A# mA Low Value[c]

A# AO Range[c]
- A# Upper Value[c]
- A# Low Value[c]

(a) Only when Meas Units is % or Custom
(b) Only if Number of Apps is 1
(c) Only if Number of Apps is > 1
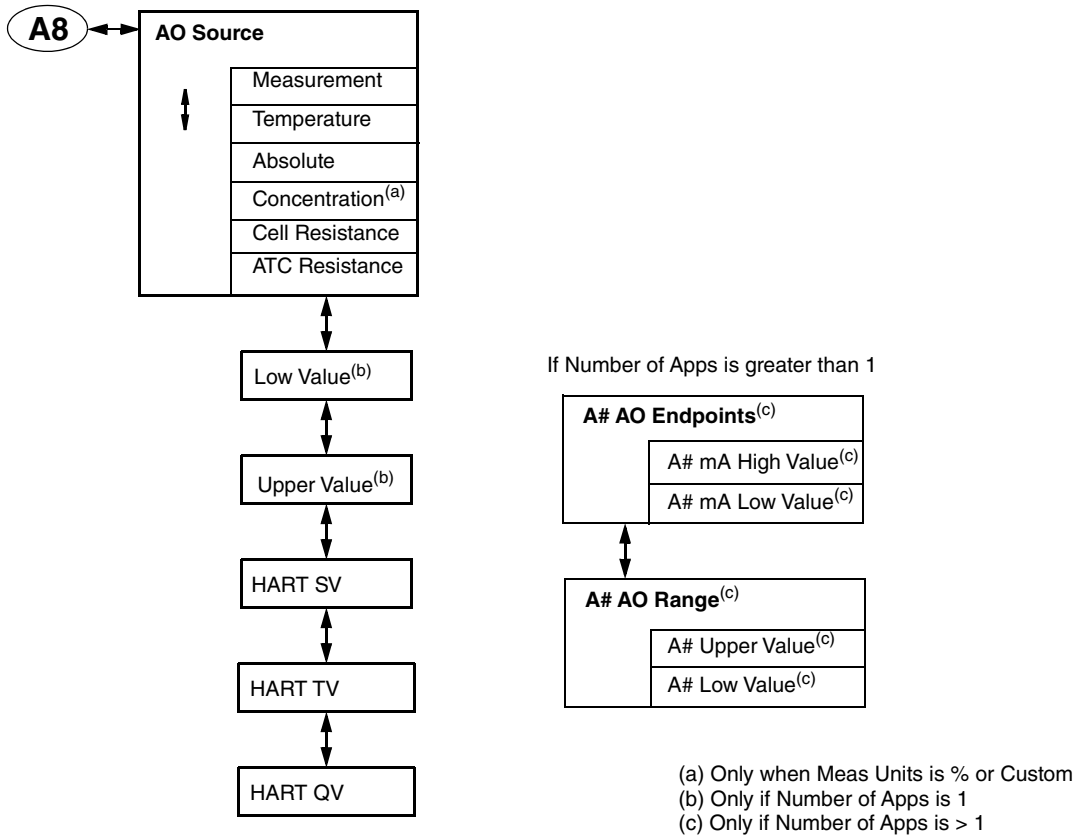
Figure 37. AO Failsafe Structure

AO Failsafe
- Off
- Fail Low
- Fail Hi
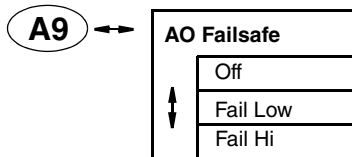
Figure 38. Measurement Display Structure

Display Format
- Single Line
- Double Line
- Triple Line

Line n
- Measurement
- Temperature
- Concentration[a]
- Absolute
- Analog Out

(a) Only when Meas Units is % or Custom
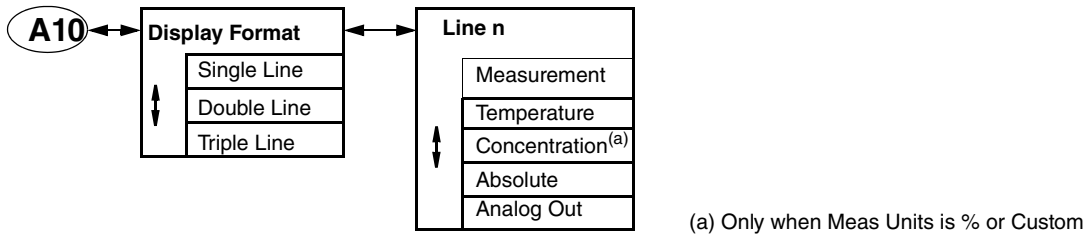
Figure 39. Run Application Structure

If Number of Apps is > 1

A11 ↔

Run Apps
Auto
App 1
App 2
App 3

↔

Auto
App 1 Hi
App 2 Lo
App 2 Hi
App 3 Lo
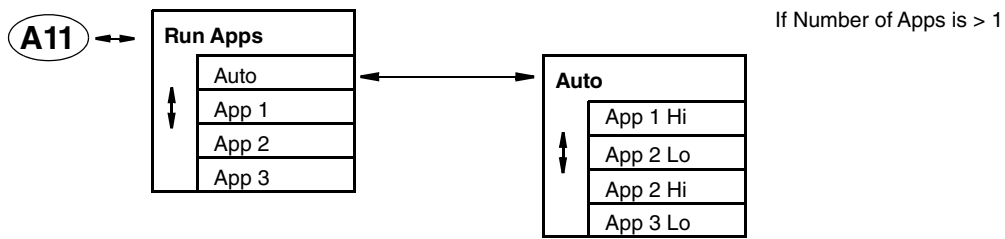
Figure 40. HART Digital Structure

HART Version 5

A12 ↔ Poll Address

↕

Preambles

↕

HART Version

HART Versions 6 and 7

A12 ↔ Poll Address

↕

mA Loop Mode

↕

Preambles

↕

HART Version
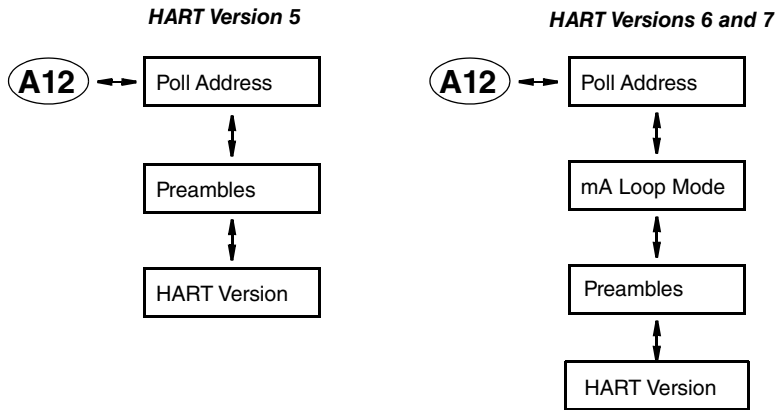
Figure 41. Diagnostics Structure

A13 ↔

Enable/Disable Diag
Enable All
Disable All
Leakage
ATC Short
ATC Open
Comp Range
Meas Range

On/Off
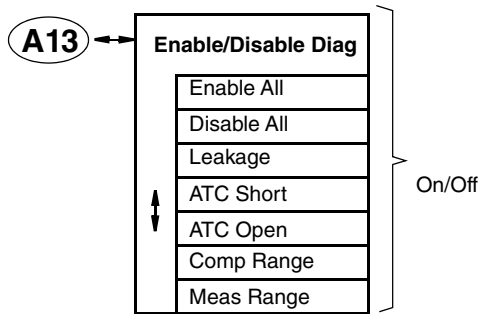
Figure 42. Auto Hold Structure

A14 ↔

Auto Hold
Off
On Present
On Manual

123

Figure 43. Timeout Structure
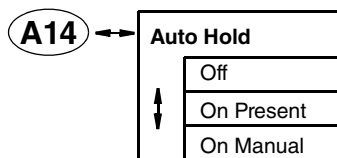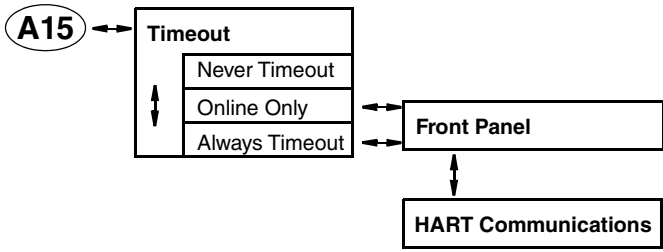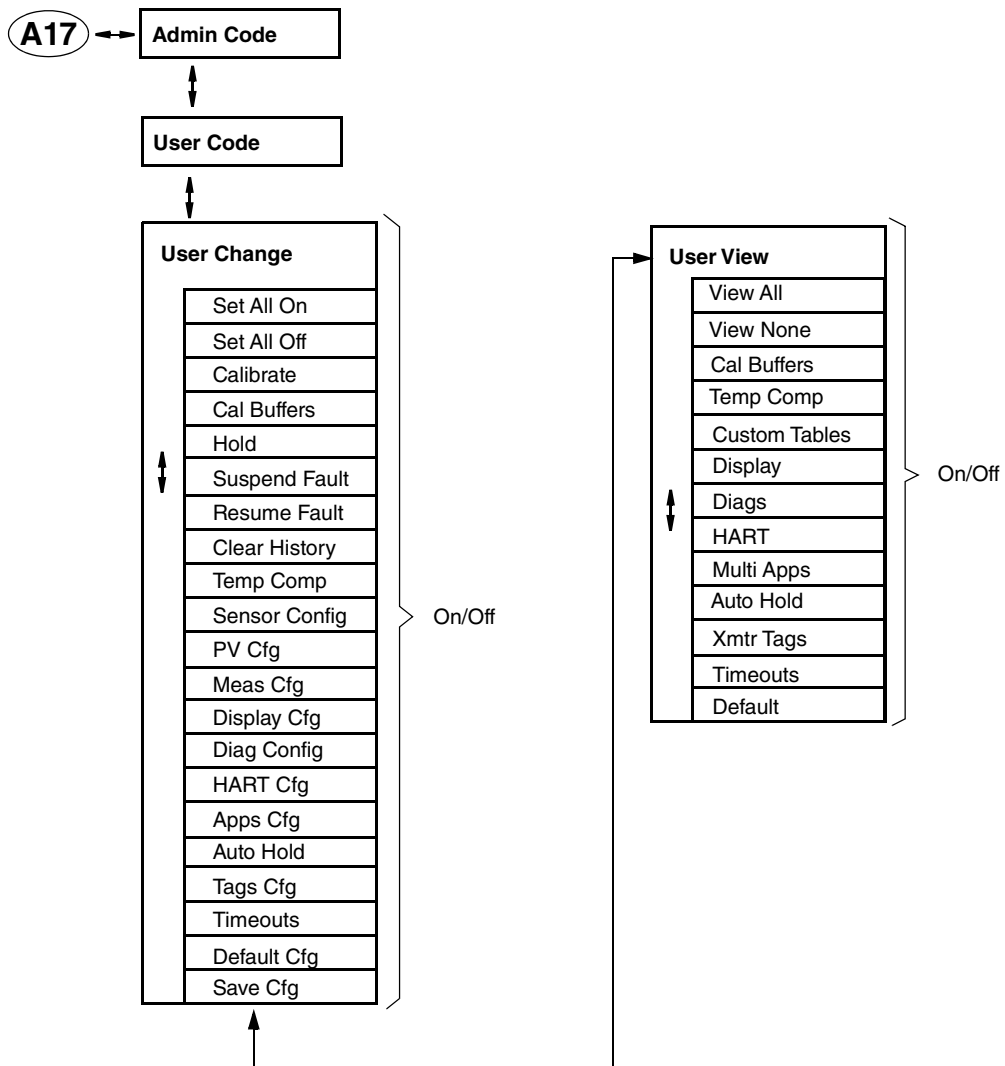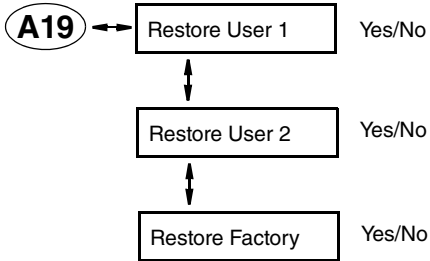

Figure 44. Transmitter Tags Structure
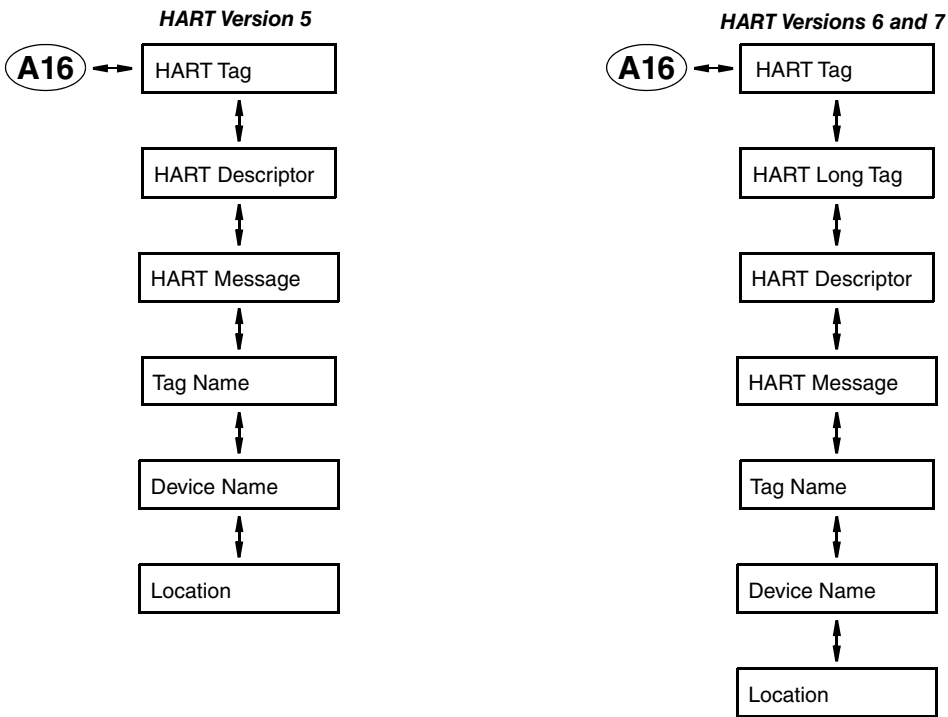
Figure 45. Passcode Access Structure

Figure 46. Stability Structure

A18 ←→ Stability

Figure 47. Restore Config Structure

A19 ←→ Restore User 1   Yes/No

Restore User 2   Yes/No

Restore Factory   Yes/No

Appendix D. Configuration Table

This appendix contains information that helps you configure your transmitter. The information is presented in the form of a table containing each prompt/parameter, its limits, and its factory default value. It also provides space for you to record your specific configuration and notations.

─ **NOTE** ─────────────────────────────────
Bold print in the Factory Configuration column indicates the configuration resulting from the Configure Factory Defaults menu.
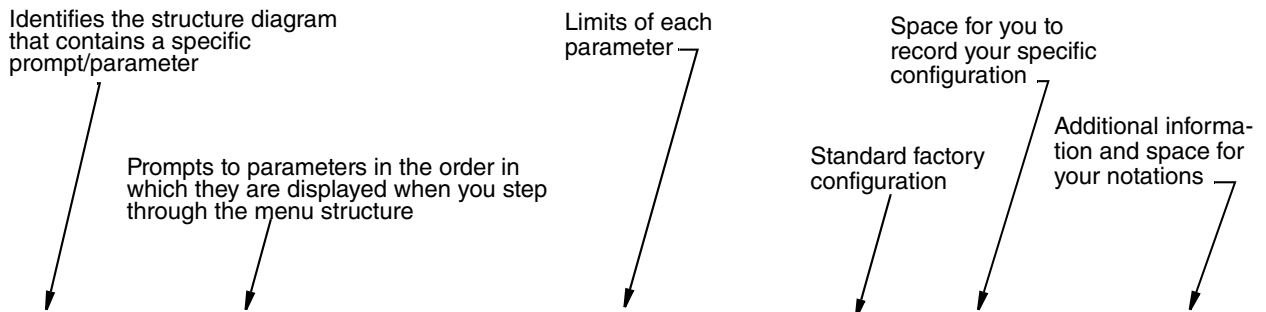──

Identifies the structure diagram that contains a specific prompt/parameter

Limits of each parameter

Space for you to record your specific configuration

Prompts to parameters in the order in which they are displayed when you step through the menu structure

Standard factory configuration

Additional information and space for your notations

Figure	Prompt/Parameter	Parameter Limits	Factory Configuration	User Configuration	Remarks and Notes
29	Configure				
	Sensor Number of Apps A# Configuration Meas Config Temp Config Temp Comp Analog Out (PV) AO Failsafe Meas Display Run Applications HART Digital Enable/Disable Diags Auto Hold Config Timeout Transmitter Tags Passcode Access Stability Restore Config	See below.	See below.		
30	Sensor Type	871EC, 871FT English, 871FT, Metric, EP307, FT10, Other	871EC		
30	871EC Type (if Sensor Type is 871EC)	SP, HP, LB, UT, RE, BW, TF, NL, EV, AB, PN, PX, PP, PT	SP		
31	Temp Type	100K Thermistor, 2-Wire Pt 100, 2-Wire Pt 1000, 3-Wire Pt 100, 3-Wire Pt 1000, Mil RTD	100K Thermistor		
32	Number of Apps	1, 2, 3	1		

Figure	Prompt/Parameter	Parameter Limits	Factory Configuration	User Configuration	Remarks and Notes
33	Meas Config (if Number of Apps is 1)				
	Meas Units	µS/cm, mS/cm, mS/m, S/m, %, Custom	mS/cm		
	Base Display Scale (If Meas Units ≠ % or Custom)	99.99, 999.9, 9999, 0.9999, 9.999	99.99		Selections vary per Cell Const and Meas Unit
	Chemical Composition (If Meas Units = %)	NaCl, KCl, CH_3COOOH, H_3PO_4, HCl, H_2SO_4, Oleum, HNO_3, NaOH, KOH, HF	NaCl		
	Custom Units (If Meas Units = Custom)	%, ppt, ppm, ppb, g/l, oz/gal, user defined, none	ppm		
	Custom Scale (If Meas Units = Custom)	99.999, 999.9, 999.99, 9999, 9999.9, 99999, 0.9999, 0.99999, 9.999, 9.9999, 99.99	999.9		
	Base Units (If Meas Units = % or Custom)	µS/cm, mS/cm, mS/m, S/m	mS/cm		
	Base Display Scale (If Meas Units = Custom)	9999, 0.9999, 9.999, 99.99, 999.9	9999		
	Num Points (If Meas Units = Custom)	2 to 21 points	2		
	Damping	1 to 300 seconds	1		
	A# Configuration (if Number of Apps > 1)				
	A# Name	0 to 12 characters	(blank)		
	A# Meas Config				
	A# Meas Units	µS/cm, mS/cm, mS/m, S/m, %, Custom	mS/cm		
	A# Base Display Scale (If A# Meas Units ≠ % or Custom)	99.99, 999.9, 9999, 0.9999, 9.999	9999		
	A# Chemical Composition (If A# Meas Units = %)	NaCl, KCl, CH_3COOOH, H_3PO_4, HCl, H_2SO_4, Oleum, HNO_3, NaOH, KOH, HF	NaCl		
	A# Base Units (If A# Meas Units = %)	µS/cm, mS/cm, mS/m, S/m	mS/cm		
	A# Custom Units (If A# Meas Units = Custom)	%, ppt, ppm, ppb, g/l, oz/gal, user defined, none	ppm		
	A# Custom Scale (If A# Meas Units = Custom)	99.999, 999.9, 999.99, 9999, 9999.9, 99999, 0.9999, 0.99999, 9.999, 9.9999, 99.99	999.9		
	A# Base Units (If A# Meas Units = Custom)	µS/cm, mS/cm, mS/m, S/m	mS/cm		
	A# Base Display Scale (If A# Meas Units = Custom)	9999, 0.9999, 9.999, 99.99, 999.9	9999		
	A# Num Points (If A# Meas Units = Custom)	2 to 21 points	2		
	A# Custom Table (If A# Meas Units = Custom)	Enter the base value for each point.	0.0 for each point (units will vary depending on Base Units and Custom Units selected)		
	A# Damping	1 to 300 seconds	5 seconds		

Figure	Prompt/Parameter	Parameter Limits	Factory Configuration	User Configuration	Remarks and Notes
34	Temp Config (A# Temp Config)				
	Temp Units	°C, °F	°C		
	Temp Mode	Auto, Manual	Auto		
	Manual Temp (if Temp Mode is Manual)	-30.00 to 200.00°C (-22 to 392°F)	25°C		
	Fail Temp (if Temp Mode is Auto)	-30.00 to 200.00°C (-22 to 392°F)	25°C		
35	Temp Comp (A# Temp Comp)				
	Temp Comp	Absolute, dilute NaCl, NaCl, Sea Water, KCl, CH_3COOH, H_3PO_4, HCl, H_2SO_4, Oleum, HNO_3, NaOH, KOH, HF, Green Liquor, Black Liquor, Linear, Custom	NaCl		
36	Analog Out (PV) (A# Analog Out (PV))				
	AO Source	Measurement, Temperature, Absolute, Concentration, Cell Resistance, ATC Resistance	Measurement		
	Upper Value	0.000 to 7166.667 mS/cm	50.000 mS/cm		
	Low Value	0.000 to 7166.667 mS/cm	0.000 mS/cm		
	A# AO Endpoints (if Number of Apps is > 1)				
	A# mA High Value		20.00 mA		
	A# mA Low Value		4.00 mA		
	HART SV	Measurement, Temperature, Absolute, Cell Resistance, ATC Resistance	Temperature		
	HART TV		Absolute		
	HART QV		ATC Resistance		
37	AO Failsafe	Off, Fail Low, Fail High	Off		
38	Meas Display				
	Display Format	Single Line, Double Line, Triple Line	Single Line		
	Line 1	Measurement, Temperature, Concentration, Absolute, Analog Out	Measurement		
	Line 2		Temperature		
	Line 3		Absolute		
39	Run Apps (if Number of Apps is > 1)	Auto, App 1, App 2, App 3	Auto		
	App 1 Hi (if Run Apps is Auto)	0 to 100,000 mS/cm	86 mS/cm		
	App 2 Lo (if Run Apps is Auto)	0 to 100,000 mS/cm	181.65 mS/cm		
	App 2 Hi (if Run Apps is Auto)	0 to 100,000 mS/cm	271.11 mS/cm		
	App 3 Lo (if Run Apps is Auto)	0 to 100,000 mS/cm	258.2 mS/cm		
40	HART Digital				
	Poll Address	0 to 15 (if HART Version is 5) 0 to 63 (if HART Version is 6 or 7)	0		
	mA Loop Mode (if HART Version is 6 or 7)	Active, Multi-Drop	Active		
	Preambles	5 to 20	7		
	HART Version	5, 6, 7	5		

Figure	Prompt/Parameter	Parameter Limits	Factory Configuration	User Configuration	Remarks and Notes
41	Enable/Disable Diags		None		
	Enable All	On, Off	Off		
	Disable All	On, Off	On		
	Leakage	On, Off	Off		
	ATC Short	On, Off	Off		
	ATC Open	On, Off	Off		
	Comp Range	On, Off	Off		
	Meas Range	On, Off	Off		
42	Auto Hold	Off, On Present, On Manual	On Manual		
43	Config Timeout				
	Timeout	Always Timeout, Never Timeout, Online Only	Always Timeout		
	Front Panel	30 to 999 seconds	600 sec		
	HART Communication	30 to 999 seconds	999 sec		
44	Transmitter Tags				
	HART Tag	0 to 8 characters	(blank)		
	HART Long Tag (if HART Version is 6 or 7)	0 to 32 characters	(blank)		
	HART Descriptor	0 to 16 characters	(blank)		
	HART Message	0 to 32 characters	(blank)		
	Tag Name	0 to 14 characters	(blank)		
	Device Name	0 to 6 characters	(blank)		
	Location	0 to 14 characters	(blank)		

Figure	Prompt/Parameter	Parameter Limits	Factory Configuration	User Configuration	Remarks and Notes
45	Passcode Access				
	Admin Code	0 to 9999	0800		
	User Code	0 to 9999	0800		
	User Change				
	Set All On	On, Off	Off		
	Set All Off	On, Off	Off		
	Calibrate	On, Off	On		
	Cal Buffers	On, Off	Off		
	Hold	On, Off	On		
	Suspend Fault	On, Off	Off		
	Resume Fault	On, Off	Off		
	Clear History	On, Off	Off		
	Temp Comp	On, Off	On		
	Sensor Config	On, Off	On		
	PV Cfg	On, Off	On		
	Meas Cfg	On, Off	On		
	Display Cfg	On, Off	On		
	Diag Config	On, Off	Off		
	HART Cfg	On, Off	Off		
	Apps Cfg	On, Off	Off		
	Auto Hold	On, Off	Off		
	Tags Cfg	On, Off	Off		
	Timeouts	On, Off	Off		
	Default Cfg	On, Off	Off		
	Save Cfg	On, Off	Off		
	User View		None		
	View All	On, Off	Off		
	View None	On, Off	On		
	Cal Buffers	On, Off	Off		
	Temp Comp	On, Off	Off		
	Custom Tables	On, Off	Off		
	Display	On, Off	Off		
	Diags	On, Off	Off		
	HART	On, Off	Off		
	Multi Apps	On, Off	Off		
	Auto Hold	On, Off	Off		
	Xmtr Tags	On, Off	Off		
	Timeouts	On, Off	Off		
	Default	On, Off	Off		
46	Stability	25.0 to 1000.0	100.0%		
	Restore Config				
	Restore User 1	Yes, No	No		
	Restore User 2	Yes, No	No		
	Restore Factory	Yes, No	No		

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