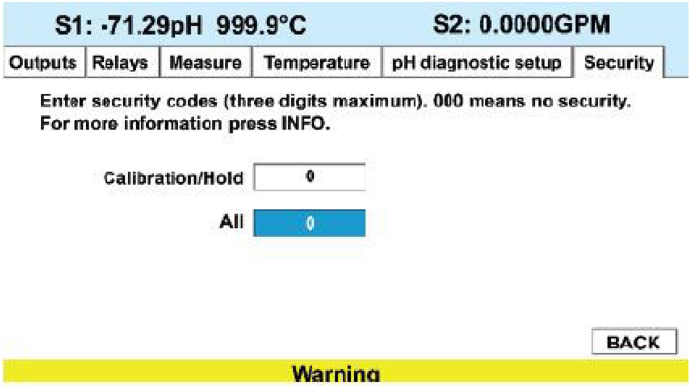


5.6 Security access

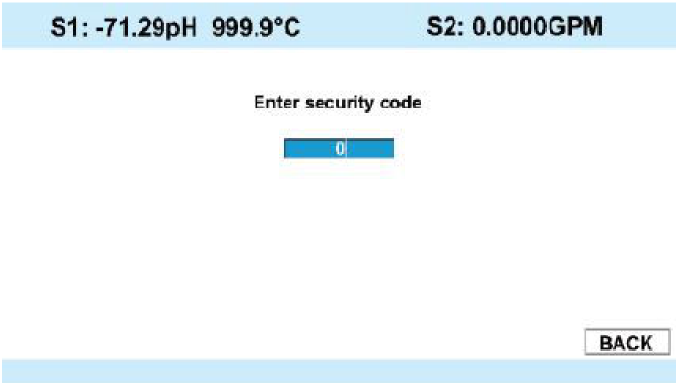
When entering the correct access code for the Calibration/Hold security level, the Calibration and Hold menus are accessible. This allows operators or technicians to perform routine maintenance. This security level does not allow access to the ***Program*** or ***Display*** menus. When entering the correct access code for All security level, the user has access to all menu functions, including Programming, Calibration, Hold and Display.

The Rosemount 56 menus use a security code, access the ***Security*** screen by pressing **ENTER/ MENU** from the main screen.

If a security code is currently programmed, the following security screen will appear. Enter the code.

Procedure

1. If a security code has been programmed, selecting the Calibrate, Hold, Program or Display top menu items causes the security access screen to appear.



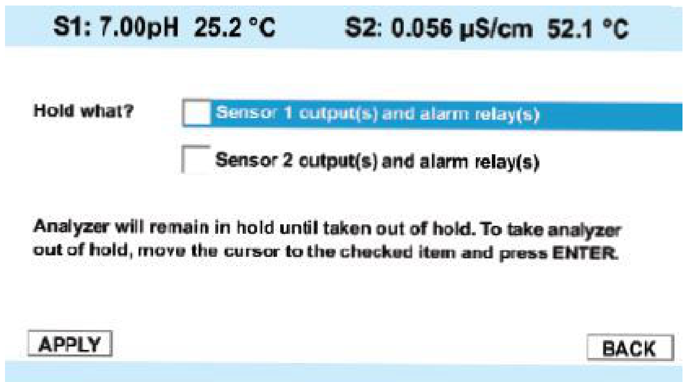
2. Enter the three-digit security code for the appropriate security level.
3. If the entry is correct, the appropriate menu screen appears. If the entry is incorrect, the Invalid Code screen appears. The Enter Security Code screen reappears after 2 seconds.

5.7 Using Hold

The analyzer output is always proportional to measured value.

Procedure

1. To prevent improper operation of systems or pumps that are controlled directly by the current output, place the analyzer in Hold before removing the sensor for calibration and maintenance.
2. Remove the analyzer from Hold once calibration is complete.
   During Hold, all outputs remain at the last value. Once in Hold, all current outputs remain on Hold indefinitely.
3. To hold the outputs and alarm relays, access the ***Hold*** screen by pressing **ENTER/ MENU** from the main screen.



5.8 Resetting factory default settings

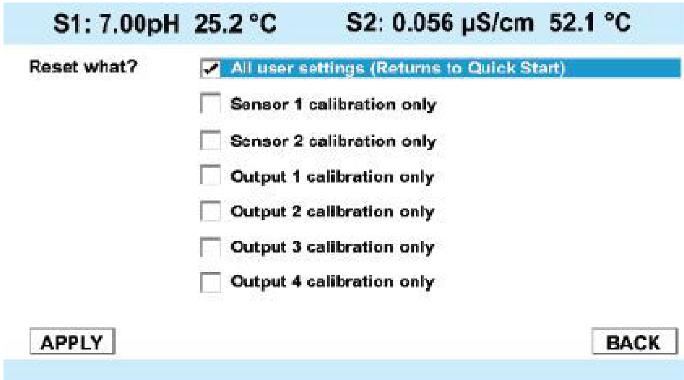
This section describes how to restore factory calibration and default values. The process also clears all fault messages and returns the display to the first Quick Start screen.

The Rosemount 56 offers three options for resetting factory defaults:

- Reset all settings to factory defaults
- Reset sensor calibration data only
- Reset analog output settings only

Procedure

To reset to factory defaults, reset calibration data only or reset analog outputs only, access the ***Reset*** screen by pressing **ENTER/MENU** from the main screen.

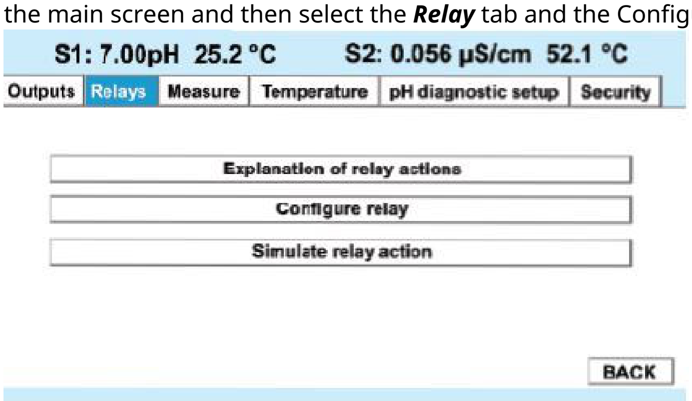


5.9 Programming alarm relays

The Rosemount 56 24 VDC (02 order code) and the AC switching power supply (03 order code) provide four alarm relays for process measurement or temperature. Each alarm can be configured as a fault alarm instead of a process alarm. Additionally, each relay can be programmed independently and each can be programmed as an interval timer or one of four advanced timer functions. This section describes how to configure alarm relays, simulate relay activation, and synchronize timers for the four alarm relays.

This section provides details to program the following alarm features.

To program the alarm relays, access the ***Program*** screen by pressing **ENTER/MENU** from the main screen and then select the ***Relay*** tab and the Configure relay control.



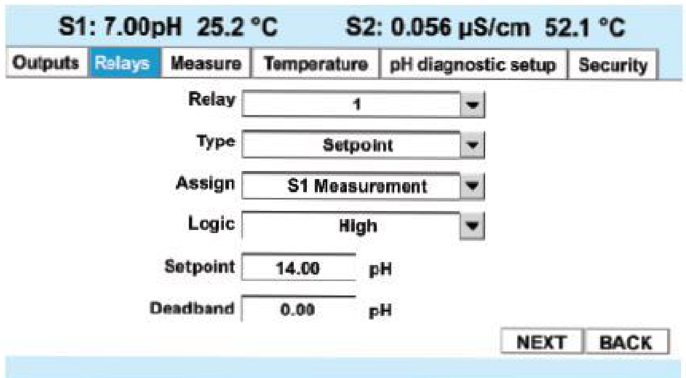
The following relay functions can be programmed to any relay from the ***Configure Relay*** screen:

1. Assign a relay
2. Define a relay function
3. Assign a Measurement
4. Set relay logic
5. Enter setpoints
6. Set deadband
7. Set normal state
8. Set USP Safety level (contacting conductivity)

To program these relay functions, access the ***Configure Relay*** screen by pressing **ENTER/ MENU** from the main ***Relay programming*** screen.

Procedure

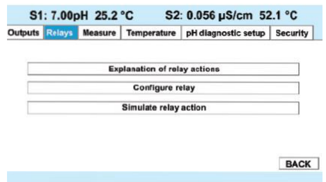
1. To assign a relay, highlight the desired Relay 1-4 and press **ENTER/MENU**.

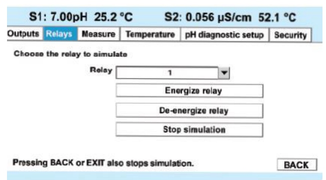


2. To define a relay function, select from **Setpoint**, **Interval Timer**, **TPC**, **Bleed and Feed**, **Water Meter**, **Delay timer**, **Date and Time**, **Fault** or **None** and press **ENTER/ MENU**.
3. To assign a measurement to a specific relay, select the desired measurement or temperature input and press **ENTER/MENU**.
4. To set relay logic to activate alarms at a **High** reading or a **Low** reading, select high or low and press **ENTER/MENU**.
5. To enter setpoints for relays, enter the desired value for the process measurement or temperature at which to activate an alarm event and press **ENTER/MENU**.
6. To set deadband as a measurement value, enter the change in the process value needed after the relay deactivates to return to normal (and thereby preventing repeated alarm activation) and press **ENTER/MENU**.
7. To set the **Normal** alarm condition, select **Open** or **Closed** and press **ENTER/ MENU**. Program the normal state to define the desired alarm default state to normally open or normally closed upon power up.
8. To set USP Safety, enter the percentage below the limit at which to activate the alarm and press **ENTER/MENU**.

   Note
   USP Safety only appears if a contacting conductivity board is installed.

   This section provides details to simulate relay action.
9. To simulate relays, access the ***Program*** screen by pressing **ENTER/MENU** from the main screen and then select the ***Relay*** tab.





10. To simulate alarm relay conditions, access the ***Simulate Relay Action*** screen by pressing **ENTER/MENU** from the main ***Relay programming*** screen.
    Alarm relays can be manually set for the purposes of checking devices such as valves or pumps.
11. Under the ***Alarms Settings*** menu, this screen will appear to allow manual forced activation of the alarm relays. Select the desired alarm condition to simulate.

6 Programming - Measurements

6.1 Programming measurements – Introduction

The Rosemount 56 automatically recognizes each installed measurement board upon first power-up and each time the analyzer is powered. Completion of Quick Start screens upon first power up enable measurements, but additional steps may be required to program the analyzer for the desired measurement application. This section covers the following programming and configuration functions:

1. Selecting measurement type or sensor type (All sections)
2. Identifying the preamp location (pH: See pH measurement programming.)
3. Enabling manual temperature correction and entering a reference temperature (All sections)
4. Enabling sample temperature correction and entering temperature correction slope (Selected sections)
5. Defining measurement display resolution (pH measurement programming and Amperometric)
6. Defining measurement display units (All sections)
7. Adjusting the input filter to control display and output reading variability or noise (All sections)
8. Selecting a measurement range (Conductivity: See Contacting conductivity measurement programming and Toroidal conductivity measurement programming.)
9. Entering a cell constant for a contacting or toroidal sensor (See Contacting conductivity measurement programming and Toroidal conductivity measurement programming.)
10. Entering a temperature element/RTD offset or temperature slope (Conductivity: See Contacting conductivity measurement programming.)
11. Creating an application-specific concentration curve (Conductivity: See Contacting conductivity measurement programming and Toroidal conductivity measurement programming.)
12. Enabling automatic pH correction for free chlorine measurement (Chlorine measurement programming)

To fully configure the analyzer for each installed measurement board, you may use the following:

- Reset Analyzer function to reset factory defaults and configure the measurement board to the desired measurement. Follow the *Reset Analyzer* menu to reconfigure the analyzer to display new measurements or measurement units.
- Program menus to adjust any of the programmable configuration items. Use the following configuration and programming guidelines for the applicable measurement.

6.2 pH measurement programming

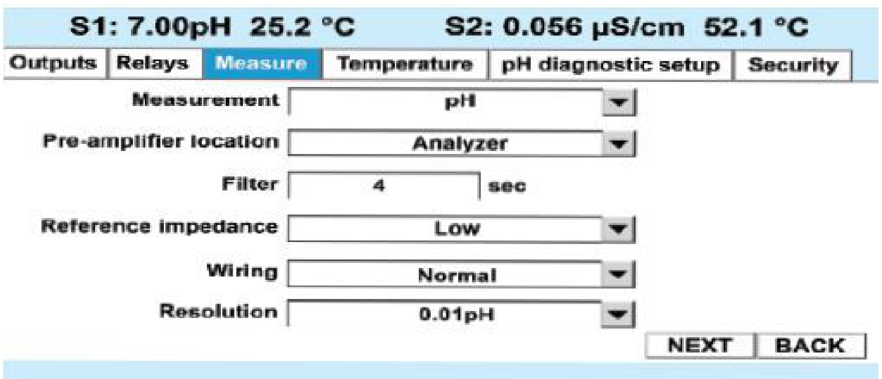
The section describes how to configure the Rosemount 56 analyzer for pH measurements. The following programming and configuration functions are covered:

1. Measurement type: pH Select pH, ORP, Redox, Ammonia, Fluoride, Custom ISE
2. Preamp location: Analyzer Identify preamp location
3. Filter: 4 sec Override the default input filter, enter 0-999 seconds
4. Reference Z: Low Select low or high reference impedance
5. Sensor wiring scheme: Normal or Reference to Ground
6. Resolution: 0.01pH Select 0.01pH or 0.1pH for pH display resolution
7. Enabling pH sensor diagnostics

To configure the pH measurement board, access the ***Program*** screen by pressing **ENTER/ MENU** from the main screen and then select the ***Measurement*** tab.

Procedure

1. To select a Measurement type, select from: **pH**, **ORP**, **Redox**, **Ammonia**, **Fluoride**, and **Custom ISE**, and press **ENTER/MENU**.



2. To program the Preamp location, select Analyzer or Sensor/JBox, and press **ENTER/ MENU**.
3. To Override the default input filter, enter 0-999 seconds and press **ENTER/MENU**.
4. To program Reference Impedance, select **Low** or **High** and press **ENTER/MENU**.
5. To choose the wiring scheme, select **Normal** or **Reference to Ground** and press **ENTER/MENU**.
6. To program the display resolution, select **0.01 pH** or **0.1 pH** and press **ENTER/ MENU**.
7. To enable pH sensor diagnostics, select the ***pH diagnostic setup*** tab under ***Programming***. Select **Sensor 1** or **Sensor 2**. Select **NEXT**. Select **On** under ***sensor diagnostics*** to enable pH diagnostics.

Note
pH sensor diagnostics must be enabled to include diagnostic values such as Glass Impedance and Reference Impedance in Excel data log sheets after data download to USB. Enabling pH sensor diagnostics also allows assignment of Glass Impedance and Reference Impedance to the two-dimensional on-screen process graph accessible under ***Display Setup/View Graph***.

6.3 ORP measurement programming

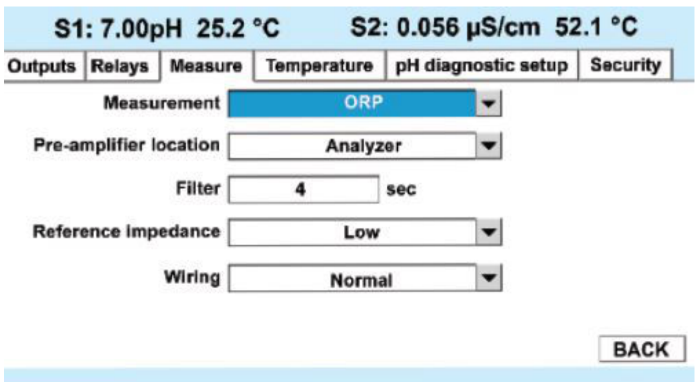
The section describes how to configure the Rosemount 56 analyzer for ORP measurements.

The following programming and configuration functions are covered:

1. Measurement type: pH Select pH, ORP, Redox, Ammonia, Fluoride, Custom ISE
2. Preamp location: Analyzer Identify preamp location
3. Filter: 4 sec Override the default input filter, enter 0-999 seconds
4. Reference Z: Low Select low or high reference impedance
5. Sensor wiring scheme: Normal or Reference to Ground

Procedure

1. To configure the ORP measurement board, access the ***Program*** screen by pressing **ENTER/MENU** from the main screen and then select the ***Measurement*** tab.

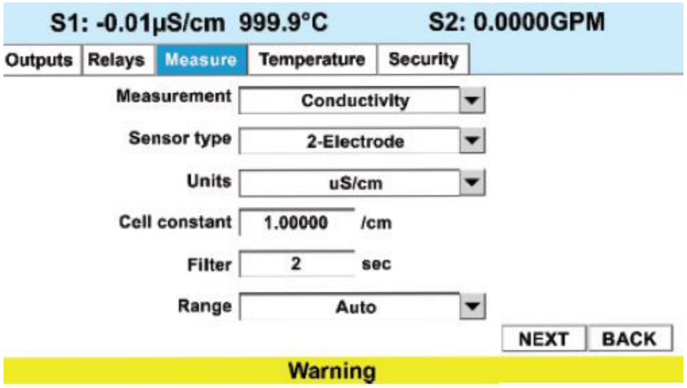


2. To select a Measurement type, select **ORP** and press **ENTER/MENU**.
3. To program the Preamp location, select **Analyzer** or **Sensor/JBox**, and press **ENTER/ MENU**.
4. To Override the default input filter, enter 0-999 seconds and press **ENTER/ MENU**.
5. To program Reference Impedance. Select **Low** or **High** and press **ENTER/MENU**.
6. Using the wiring scheme, select **Normal** or **Reference to Ground** and press **ENTER/ MENU**.

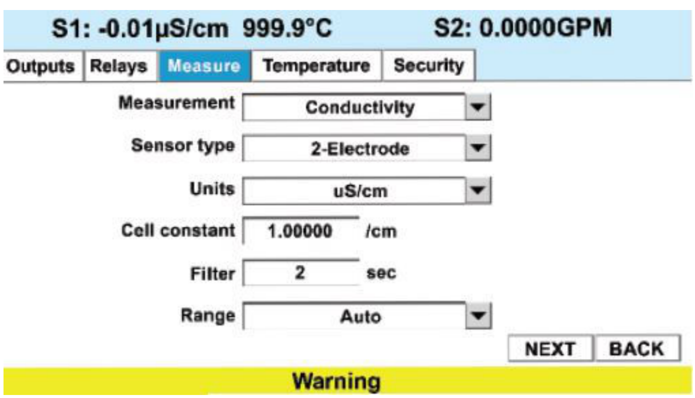
6.4 Contacting conductivity measurement programming

The section describes how to configure the Rosemount 56 analyzer for conductivity measurements using contacting conductivity sensors.

The following programming and configuration functions are covered:



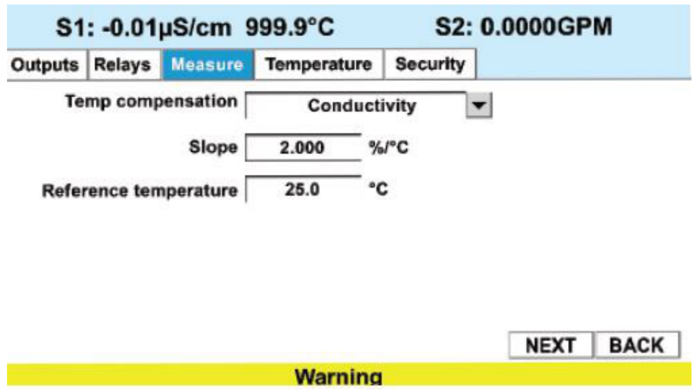
1. Measure: Conductivity. Select Conductivity, Resistivity, TDS. Salinity or % conc.
2. Type: 2-Electrode Select 2-Electrode or 4-Electrode type sensors.
3. Cell K: 1.00000/cm. Enter the cell Constant for the sensor.
4. Measurement units
5. Filter: 2 sec. Override the default input filter and enter 0-999 seconds.
6. Range: Auto Select measurement Auto-range or specific range.
7. Temp Comp: Slope Select Temp Comp: Slope, Neutral Salt, Cation or Raw.
8. Slope: 2.00% / °C. Enter the linear temperature coefficient.
9. Ref Temp: 25.0 °C. Enter the Reference temp.
10. Cal Factor: Default = 0.95000/cm. Enter the Cal Factor for 4-Electrode sensors from the sensor tag.



To configure the contacting conductivity measurement board, access the ***Program*** screen by pressing **ENTER/MENU** from the main screen and then select the ***Measurement*** tab.

Procedure

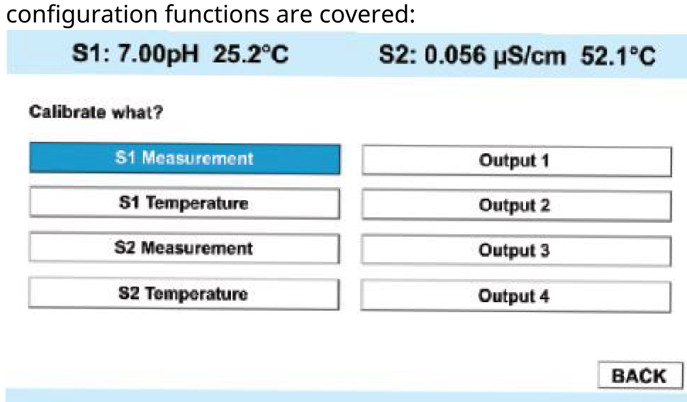
1. To program a Measurement type, select Conductivity, Select Conductivity, Resistivity, TDS. Salinity or % conc. and press **ENTER/MENU**.



2. To program a sensor type, select 2-Electrode Select 2-Electrode or 4-Electrode type sensors and press **ENTER/MENU**.
3. To program the Cell constant, enter the exact cell constant value expressed as 1.XXXXX/cm the for the sensor and press **ENTER/MENU**.
4. To program Measurement units, select uS/cm or mS/cm and press **ENTER/ MENU**.
5. To Override the default input filter, enter 0-999 seconds and press **ENTER/ MENU**.
6. To program the measurement range, select a specific range appropriate for your process and press **ENTER/MENU**.
7. To program the Temp Comp method, choose Slope, Neutral Salt, Cation or Raw and press **ENTER/MENU**.
8. To change the Temperature compensation Slope, enter the linear temperature coefficient expressed as X.XX% / °C and press **ENTER/MENU**.

6.5 Toroidal conductivity measurement programming

The section describes how to configure the Rosemount 56 analyzer for conductivity measurements using inductive/toroidal sensors. The following programming and configuration functions are covered:



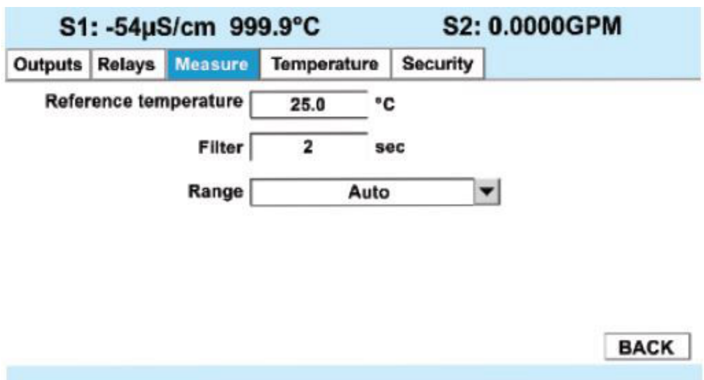
1. Measure: Conductivity Select Conductivity, Resistivity, TDS. Salinity or % conc
2. Sensor model: 228 Select sensor type / 225 Select sensor type
3. Measurement units

4. Cell K: 3.00000/cm Enter the cell constant for the sensor (228 is 2.7/cm, 225 is 3.0/cm)
5. Temp Comp: Slope Select Temp Comp: Slope, Neutral Salt, Cation or Raw
6. Slope: 2.00% / °C Enter the linear temperature coefficient
7. Ref Temp: 25.0 °C Enter the Reference temp
8. Filter: 2 sec Override the default input filter, enter 0-999 seconds
9. Range: Auto Select measurement Auto-range or specific range

To configure the ***Contacting conductivity measurement*** board, access the ***Program*** screen by pressing **ENTER/MENU** from the main screen and then select the ***Measurement*** tab.

Procedure

1. To program a Measurement type, select Conductivity Select Conductivity, Resistivity, TDS. Salinity or % conc. and press **ENTER/MENU**.



2. To program the sensor model, select 228 or other toroidal model number and press **ENTER/MENU**.
3. To program Measurement units, select uS/cm or mS/cm and press **ENTER/MENU**.
4. To program the Cell constant, enter the exact cell constant value expressed as 3.XXXXX/cm the for the sensor and press **ENTER/MENU**.
5. To program the Temp Comp method, choose Slope, Neutral Salt, Cation or Raw and press **ENTER/MENU**.
6. To change the Temperature compensation Slope, enter the linear temperature coefficient expressed as X.XX% / °C and press **ENTER/MENU**.

6.6 Chlorine measurement programming

The section describes how to configure the Rosemount 56 analyzer for Chlorine measurements.

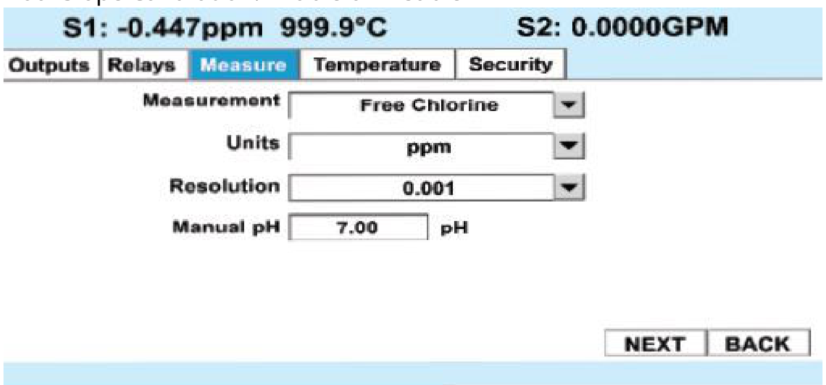
With a Chlorine measurement board installed, the Rosemount 56 can measure any of four variants of Chlorine:

- Free Chlorine
- Total Chlorine
- Monochloramine
- pH-independent Free Chlorine

6.7 Free chlorine measurement programming

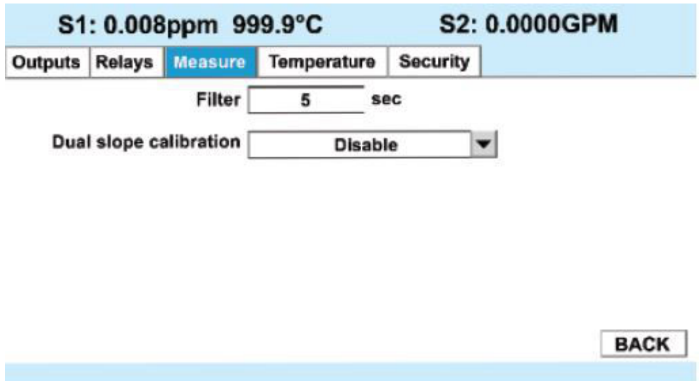
This Chlorine sub-section describes how to configure the Rosemount 56 analyzer for Free Chlorine measurement using amperometric chlorine sensors. The following programming and configuration functions are covered:

1. Measure: Free Chlorine Select Free Chlorine, pH Ind. Free Cl. Total Cl, Monochloramine
2. Units: ppm Select units ppm or mg/L
3. Resolution: 0.001 Select display resolution 0.01 or 0.001
4. Free Cl Correct: Live Select Live/ Continuous pH correction or Manual
5. Manual pH: 7.00 pH For Manual pH correction, enter the pH value
6. Filter: 5 sec Override the default input filter, enter 0-999 seconds
7. Dual Slope Calibration: Enable or Disable



Procedure

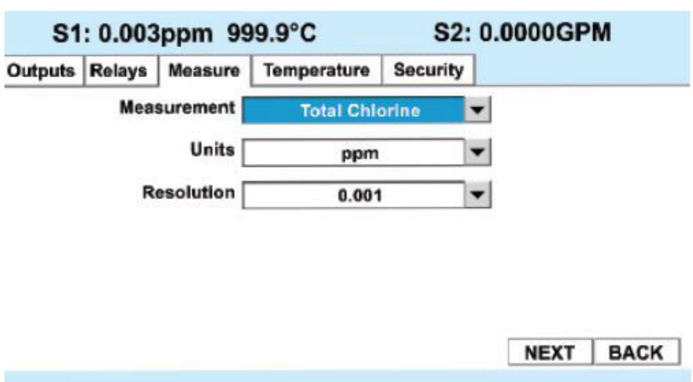
1. To program the Measurement type, select Free Chlorine, pH Ind Free Cl., Total Cl, or Monochloramine and press **ENTER/MENU**.
2. To program the Measurement Units: select ppm mg/L and press **ENTER/MENU**.
3. To program the Measurement Resolution: Select 0.01 or 0.001 and press **ENTER/ MENU**.
4. To program Free Cl Correction, select Live/Continuous pH correction or Manual and press **ENTER/MENU**.
5. To program for Manual pH correction, enter the pH value and press **ENTER/ MENU**.
6. To Override the default input filter, enter 0-999 seconds and press **ENTER/ MENU**.
7. To use Dual Slope Calibration, select Enable or Disable and press **ENTER/MENU**.



6.8 Total chlorine measurement programming

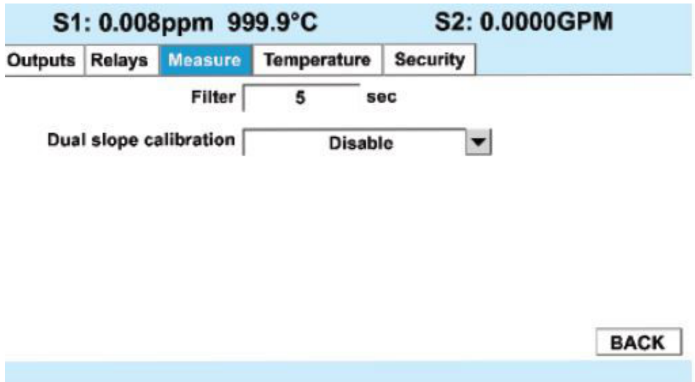
This Chlorine sub-section describes how to configure the Rosemount 56 analyzer for Total Chlorine measurement using amperometric chlorine sensors. The following programming and configuration functions are covered:

1. Measure: Free Chlorine Select Free Chlorine, pH Ind. Free Cl. Total Cl, Monochloramine
2. Units: ppm Select units ppm or mg/L
3. Resolution: 0.001 Select display resolution 0.01 or 0.001
4. Filter: 5 sec Override the default input filter, enter 0-999 seconds
5. Dual Slope Calibration: Enable or Disable



Procedure

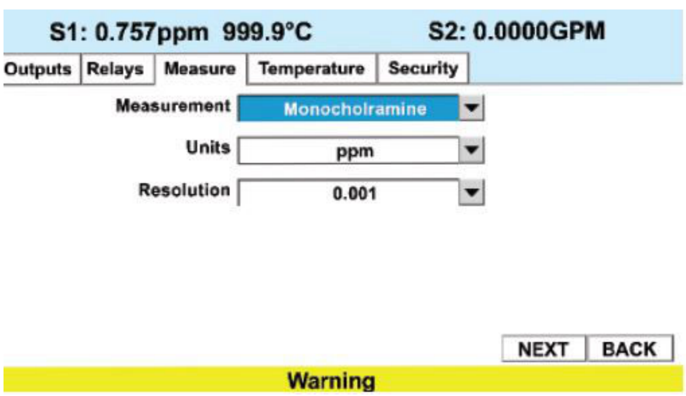
1. To program the Measurement type, select Free Chlorine, pH Ind Free Cl., Total Cl, or Monochloramine and press **ENTER/MENU**.
2. To program the Measurement Units: select ppm mg/L and press **ENTER/MENU**.
3. To program the Measurement Resolution: Select 0.01 or 0.001 and press **ENTER/ MENU**.
4. To Override the default input filter, enter 0-999 seconds and press **ENTER/ MENU**.
5. To use Dual Slope Calibration, select Enable or Disable and press **ENTER/MENU**.



6.9 Monochloramine measurement programming

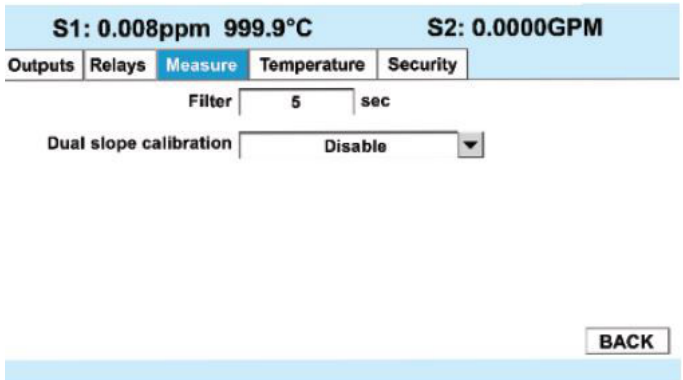
This Chlorine sub-section describes how to configure the Rosemount 56 analyzer for Monochloramine measurement using amperometric chlorine sensors. The following programming and configuration functions are covered:

1. Measure: Free Chlorine Select Free Chlorine, pH Ind. Free Cl. Total Cl, Monochloramine
2. Units: ppm Select units ppm or mg/L
3. Resolution: 0.001 Select display resolution 0.01 or 0.001
4. Filter: 5 sec Override the default input filter, enter 0-999 seconds
5. Dual Slope Calibration: Enable or Disable



Procedure

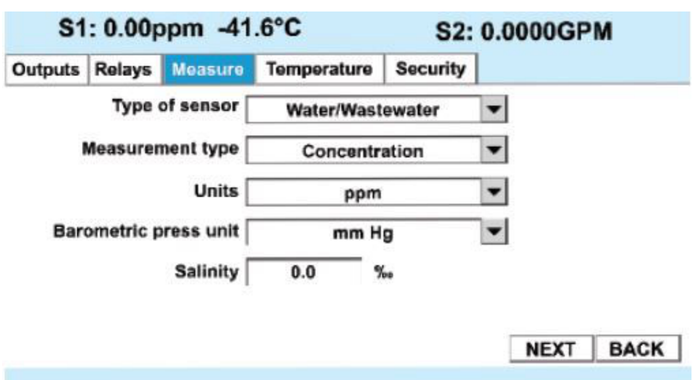
1. To program the Measurement type, select Free Chlorine, pH Ind Free Cl., Total Cl, or Monochloramine and press **ENTER/MENU**.
2. To program the Measurement Units: select ppm mg/L and press **ENTER/MENU**.
3. To program the Measurement Resolution: Select 0.01 or 0.001 and press **ENTER/ MENU**.
4. To Override the default input filter, enter 0-999 seconds and press **ENTER/ MENU**.
5. To use Dual Slope Calibration, select Enable or Disable and press **ENTER/ MENU**.



6.10 Oxygen measurement programming

This section describes how to configure the Rosemount 56 analyzer for dissolved and gaseous oxygen measurement using amperometric oxygen sensors. The following programming and configuration functions are covered:

1. Sensor type: Select Water/Waste, Trace. BioRx, BioRx-Other, Brew, %O2 In Gas
2. Measure type: Select Concentration, % Saturation, Partial Pressure, Oxygen in Gas
3. Units: ppm Select ppm, mg/L, ppb, µg/L, % Sat, %O2-Gas, ppm Oxygen-Gas
4. Pressure Units: bar Select pressure units: mm Hg, in Hg,. Atm, kPa, mbar, bar
5. Use Press: At Air Cal Select atmospheric pressure source – internal or mA Input
6. Salinity: 00.0‰ Enter Salinity as ‰
7. Filter: 5 sec Override the default input filter, enter 0-999 seconds
8. Partial Press: mmHg Select mm Hg, in Hg. atm, kPa, mbar or bar for Partial pressure



6.11 Ozone measurement programming

This section describes how to configure the Rosemount 56 analyzer for ozone measurement using amperometric ozone sensors. The following programming and configuration functions are covered:

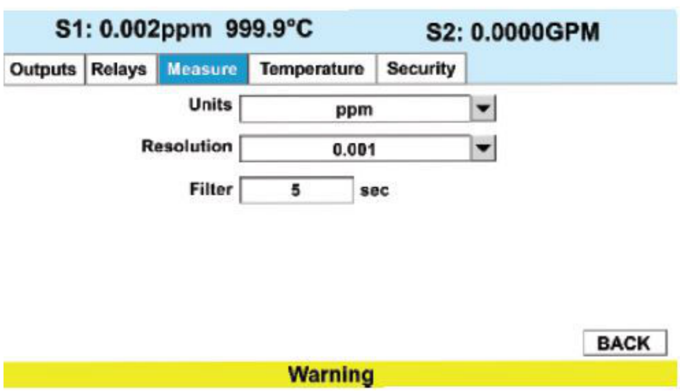
1. Units: ppm Select ppm, mg/L, ppb, µg/L

2. Resolution: 0.001 Select display resolution 0.01 or 0.001
3. Filter: 5 sec Override the default input filter, enter 0-999 seconds

6.12 Turbidity measurement programming

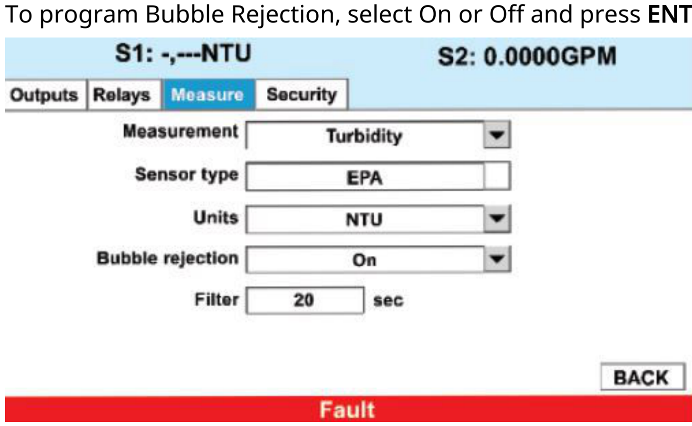
This section describes how to configure the Rosemount 56 analyzer for Turbidity measurements. The following programming and configuration functions are covered:

1. Measurement type: Turbidity Select Turbidity or TSS calculation (estimated TSS)
2. Sensor type: Select EPA or ISO
3. Measurement units: NTU, FTU, FNU
4. Filter: 20 sec Override the default input filter, enter 0-999 seconds
5. Bubble Rejection: On Intelligent software algorithm to eliminate erroneous readings caused by bubble accumulation in the sample.



Procedure

1. To program the Measurement type, Select Turbidity or TSS calculation (estimated TSS) and press **ENTER/MENU**.
2. To program the Sensor type: Select EPA or ISO and press **ENTER/MENU**.
3. To program Measurement units: NTU, FTU, FNU and press **ENTER/MENU**.
4. To Override the default input filter, enter 0-999 seconds and press **ENTER/ MENU**.
5. To program Bubble Rejection, select On or Off and press **ENTER/MENU**.



6.13 Flow measurement programming

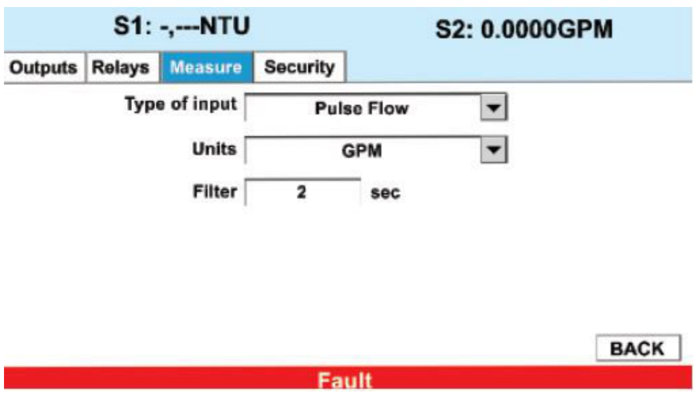
This section describes how to configure the Rosemount 56 analyzer for flow measurement when used with a compatible pulse flow sensor. The following programming and configuration functions are covered:

To program pulse flow, scroll to the desired item and press **ENTER**.

The following sub-sections provide you with the initial display screen that appears for each programming routine.

Procedure

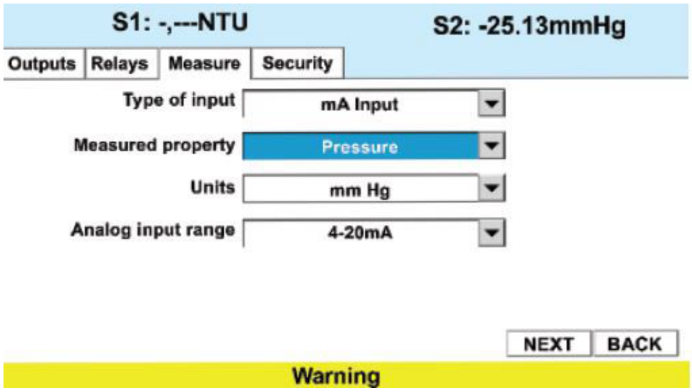
1. To program Measurement type, select Pulse Flow or mA Current Input and press **ENTER/MENU**.
2. To program Measurement units: Select GPM, GPH, cu ft/min, cu ft/hour, LPM, L/hour, or m3/hr. and press **ENTER/MENU**.
3. To Override the default input filter (5 seconds), enter 0-999 seconds and press **ENTER/MENU.**



6.14 Current input programming

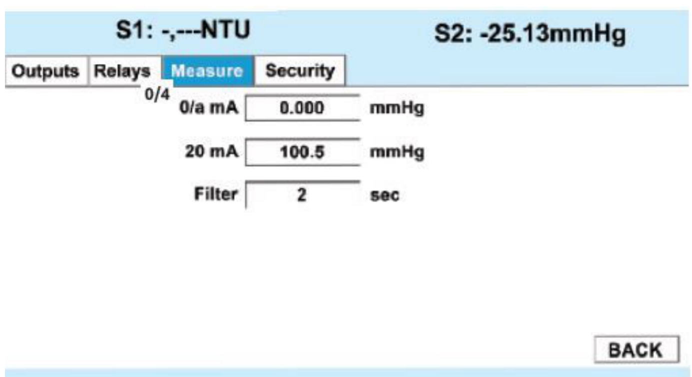
This section describes how to configure the Rosemount 56 analyzer for current input measurement when wired to an external device that transmits 4-20 mA or 0-20 mA analog current output. The following programming and configuration functions are covered.

1. Measurement type mA input Override the default (Flow) and select mA current input
2. mA Input Temperature Select Temperature, Pressure, Flow or Other
3. Measurement units: °C. Select measurement units based on selected input device type
4. Input Range: 4-20 mA Select 4-20 mA or 0-20 mA
5. Low Value: 0.000oC Enter the low measurement value to assign to 4 mA
6. High Value: 100.0oC Enter the high measurement value to assign to 20mA
7. Filter: 05 sec Override the default input filter, enter 0-999 seconds



Procedure

1. To override the default the Measurement type (Flow) select mA current input and press **ENTER/MENU**.
2. To program the mA Input type, Select Temperature, Pressure, Flow or other and press **ENTER/ MENU**.
3. To program measurement units, Select measurement units based on selected input device type and press **ENTER/MENU**.
4. To program the Input Range: Select 4-20 mA or 0-20 mA and press **ENTER/ MENU**.
5. To program the Low input Value, enter the low measurement value to assign to 4mA and press **ENTER/MENU**.
6. To program the High input Value, enter the high measurement value to assign to 20mA and press **ENTER/MENU**.
7. To override the default input filter, enter 0-999 seconds and press **ENTER/ MENU**.



7 PID control

7.1 Introduction

7.1.1 Measurement and set point (Feedback control)

The Rosemount 56 controller is given two items of information: measurement and set point. The controller reacts to the difference in value of these two signals and produces an analog output signal to eliminate that difference. As long as the difference exists, the controller will try to eliminate it with the output signal. When measurement and set point are equal, the condition of the controller is static and its output is unchanged. Any deviation of measurement from set point will cause the controller to react by changing its output signal.

7.1.2 Proportional mode

The simplest control is proportional control. In this control function, the error from set point, divided by the control range, is multiplied by the Gain constant to produce the output.

The control range is the percent of the analog output span (the difference between the 4 (or 0) mA and 20 mA settings) through which the measured variable must move to change the output from minimum to maximum.

The smaller the Gain, the less the controller reacts to changes in the measured variable. The larger the Gain, the more the controller reacts to changes in the measured variable.

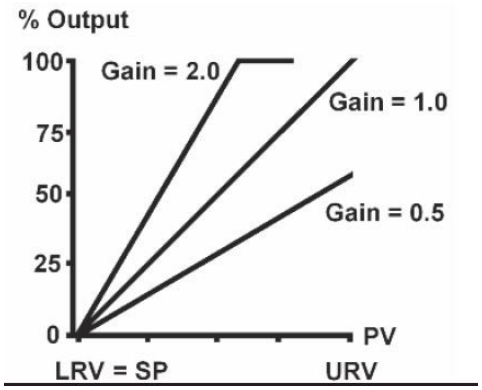
The proportional control output is given by the expression below. As can be seen, the overall gain is determined by the control range chosen (URV and LRV) and the Gain:

Proportional Output (%) = Gain * (PV – SP) * 100 / (URV, upper range value and LRV, lower range value).

Direct acting control action

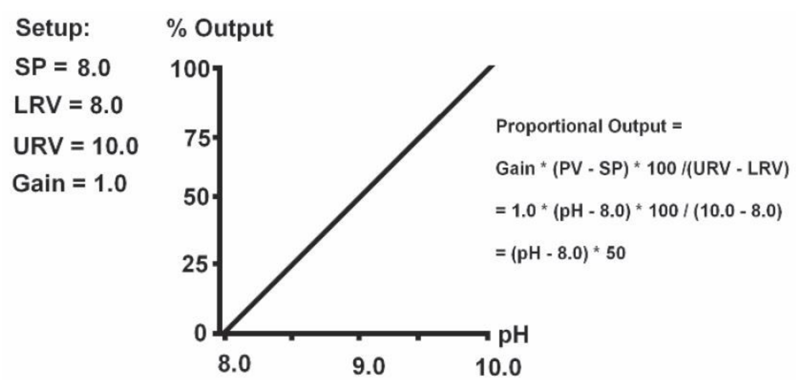
Direct acting control action increases the control output as the measured variable increases above the setpoint. The LRV is usually set to the setpoint value, so that the control output is 0% at the setpoint, and the URV is greater than the setpoint so that the 100% control output is at a higher measurement value. The Gain parameter can then be adjusted to produce the desired gain.

Figure 7-1: Direct Acting Control



Example of direct acting control: Lower the pH of a solution at 10 pH by adding acid to control it at 8 pH with the Gain parameter assumed to be 1.0. The higher the measured pH, the more acid is required to lower the pH toward the setpoint, but as the pH approaches the setpoint less acid is required:

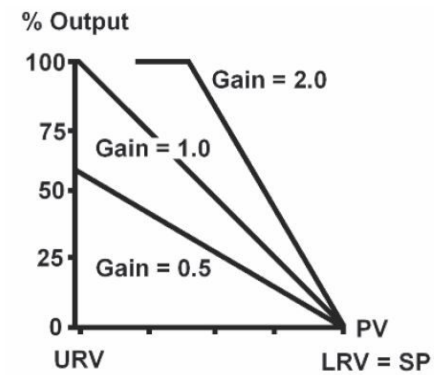
Figure 7-2: Example of Direct Acting Control



Reverse acting control action

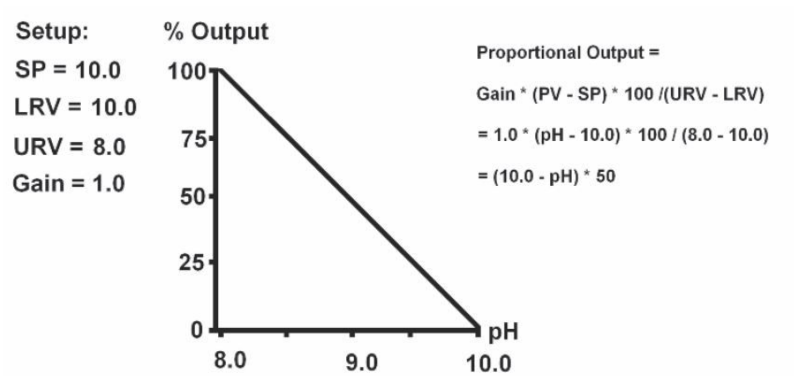
Reverse acting control action, decreases the control output as the measured variable increases toward the setpoint. The LRV is usually set to the setpoint value, so that the control output is 0% at the setpoint, and the URV is less than the setpoint value so that the 100% control output is at a lower measurement value. The Gain can then be adjusted to produce the desired gain.

Figure 7-3: Reverse acting control



Example of reverse acting control: Add base to a solution at 8.0 pH, to control the pH to 10.0 pH with an assumed Gain parameter of 1.0. The lower the measured pH, the more base is required to raise the pH toward the setpoint, but as the pH approaches the setpoint less base is required:

Figure 7-4:



7.1.3 Proportional bias

Most processes require that the measured variable be held at the set point. The proportional mode alone will not automatically do this, if an output greater than 0% is needed to keep the PV at setpoint. At setpoint, the control output is 0%, and if a non-zero control output is needed to keep the PV at the setpoint, proportional alone will only stabilize the measured variable at some offset (deviation) from the desired setpoint.

Bias is used to provide a constant control output at the setpoint to maintain PV at the setpoint. The effect of Bias is expressed as follows:

Proportional Output ( ) = [Gain * (PV – SP) * 100 / (URV – LRV)] + BIAS

Figure 7-5: Direct Acting Control with Bias

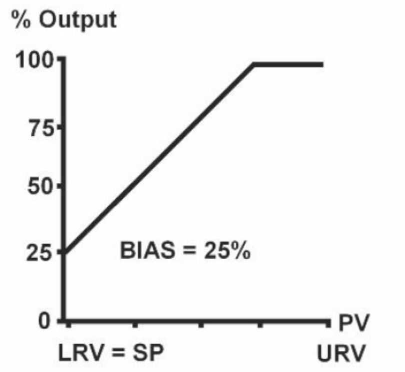
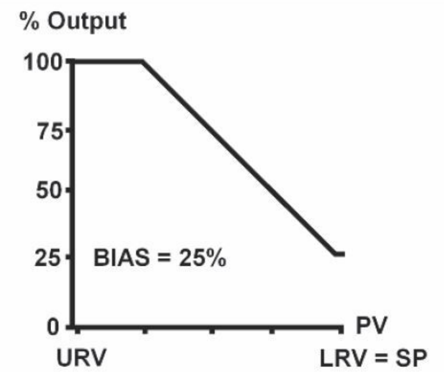


Figure 7-6: Reverse Acting Control with Bias



7.1.4 Proportional plus integral (Reset)

For the automatic elimination of deviation, Integral mode, also referred to as Reset, is used. The proportional function is modified by the addition of automatic reset, rather than a constant Bias value. With the reset mode, the controller continues to change its output until the deviation between measurement and set point is eliminated.

The action of the reset mode depends on the overall gain. The rate at which it changes the controller output is based on the overall gain band size and the reset time (I). The reset time is the time required for the reset mode to repeat the proportional action once. It is expressed as seconds per repeat, adjustable from 0-3,000 seconds.

The reset mode repeats the proportional action as long as an offset from the set point exists. Reset action is cumulative. The longer the offset exists, the more the output signal is increased. If the PV overshoots the setpoint, the reset action will decrease. When the measurement reaches the setpoint and the proportional control action becomes zero, there will be an accumulated integral control action to keep the process at the setpoint.

The controller configured with reset continues to change until there is no offset. If the offset persists, the reset action eventually drives the controller output to its 100% limit - a condition known as "reset windup".

Once the controller is "wound up", the deviation must be eliminated or redirected before the controller can unwind and resume control of the measured variable. The integral time can be cleared and the "windup" condition quickly eliminated by manually overriding the

Rosemount 56 analog output using the manual mode to reduce the control output and then setting the reset time to 0 seconds to make integral control action 0%. The reset time can then be changed to avoid reset windup.

The proportional plus integral control output is given below. Note that the larger the reset time (I), the slower the integral response will be:

Output = [Gain × 100 / (URV – LRV)] × [(PV – SP) + 1/I (PVt – SP) Δt]

7.1.5 Derivative mode (Rate)

Derivative mode provides a 3rd control mode, which responds to the rate of change of the Proportional control output, multiplied by the Derivative parameter D which has units of seconds. The contribution of the derivative response is given below:

Output = [Gain × 100 / (URV – LRV)] × D × [(PVt – SP) – (PVt-1 – SP)] / Δt

The purpose of derivative action is to provide a quick control response to changes in the measured parameter. In general, it is not often used in concentration control, and in fact, it has been estimated that 90 to 95% of all control applications use only Proportional plus Integral control. Any noise in the measurement causes problems with derivative action. Temperature measurements tend to be less noisy than other measurements, and derivative action is most often used for temperature control.

7.1.6 Process characterization and tuning

Control loops are tuned by the choice of the control range and the selection of the control parameters. How these parameters are chosen should depend on how the process responds to controller output. The process response is characterized by certain behaviors, which are due to such factors as mixing and reaction time, response time of the process to control output changes, and the characteristics of the final operator, i.e. control values, pumps, heaters, etc. With these characteristics known, initial control settings can be developed.

A good reference to PID control is provided by the book, “Control Loop Foundation—Batch and Continuous Processes”, by Terrence Blevins and Mark Nixon, International Society of Automation, Research Triangle Park, NC, © 2011.

A guide to tuning control is provided by the book, “Good Tuning: A Pocket Guide”, by Gregory K. McMillan, International Society of Automation, Research Triangle Park, NC, © 2005.

7.2 PID setup

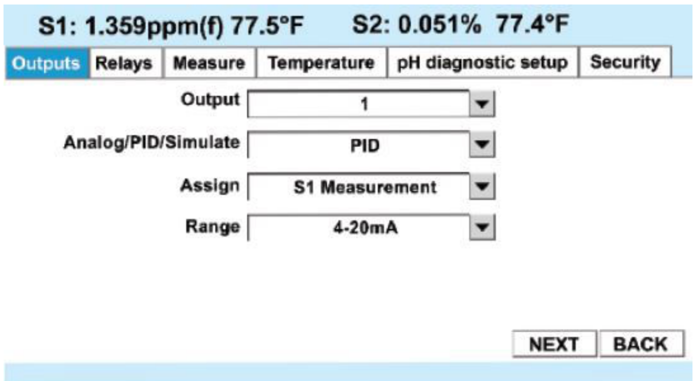
7.2.1 PID control

The Rosemount 56 current ¬outputs (one or all four) can be programmed for PID control. PID control can be applied to any of the measurements provided by the sensor boards, such as pH, conductivity, and concentrations. In addition, PID control can be applied to temperature and any measurement input to the Rosemount 56 using the flow/4-20 mA board.

The output signal of PID control is used with a final control element, which can vary is output from 0 to 100% in response to the control signal. Final control elements can include control valves, pumps or heaters.

7.2.2 Selecting PID control

Select PID control, the analog output to be used, and the measurement and range from the main analog output setup window:



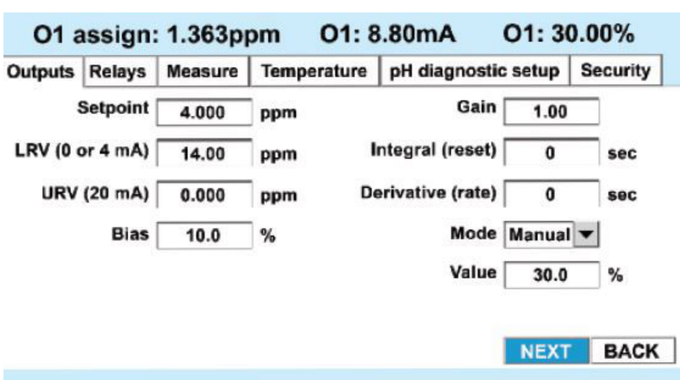
Basic Definitions:

- Output – Select the analog output (1 through 4) to be configured for PID control.
- Analog/PID/Simulate – Choose PID
- Assign – Select the Measurement to be controlled. Note: This measurement can also be a 4-20 mA signal input brought in by the flow/ 4-20 mA board.
- Range – Select either 0-20 mA or 4-20 mA range, depending on the signal range used by the final control element, e.g. a pump or valve.
- Select Next to go to the PID Setup parameters.

7.2.3 PID setup parameters

The PID control setup window contains the PID control tuning parameters.

Also note that the upper portion of the screen shows the measurement chosen for control (PV), and the control output in mA and % Output. This makes it possible to observe the primary variable (PV) and the control output, in terms of percent and milliamps, while tuning PID control.



PID Control Parameters: Basic Definitions

- Setpoint – Select the desired setpoint.

- URV – The value of PV (in the above example, 14.00 pH) at which the control will be 20 mA or 100% output.
- LRV -- The value of PV (in the above example 0.00 pH) at which the control will be 0 or 4 mA or 0% output.

Note
If you want the control output to increase as PV (in this case pH) increases, URV should be greater than LRV. This is direct acting control action. Examples of direct acting control are the addition of acid to decrease pH and adding water to a solution to decrease the concentration.

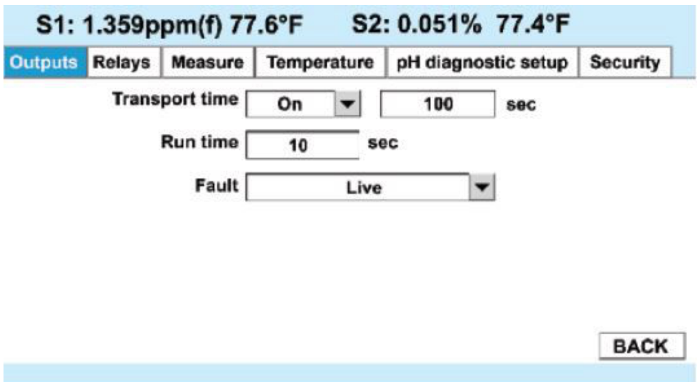
Note
If you want the control output to decrease as PV increases, i.e. reverse acting control action, the URV should be less than LRV. Examples of reverse acting control are adding caustic to increase pH and adding a concentrated solution to water to make a solution of lower concentration.

- Bias (range: 0 to 100%; default 0%) – Bias is a fixed control output which allows the con-trol output to be greater than zero when the measurement (PV) is at setpoint. It is used in proportional only control to prevent cycling resulting from the control output going to zero at the setpoint.
- Gain (range: 0.0 to 1000.0; default 0.0) – In proportional (P) only control, the output is directly proportional to the difference between the process variable (PV) and the set-point divided by the output span (URV – LRV). Gain is a factor which multiplies the pro-portional output to meet the requirements of the process being controlled. Using Gain values less than 1 reduce the proportional output while Gain values greater than 1 increase the proportional output.
- Integral (Reset, I) (range: 0 to 3,000 seconds; default 0 seconds) – Integral repeats the proportional action in a time period given by the reset time (I). The reset time is given in seconds per repeat and is adjustable from 0 to 3,000 seconds. Integral control acts as an automatic bias which increases or decreases the overall control output in response to the error (PV – SP) to keep the PV at the setpoint.
- Derivative (Rate, D) (range: 0 to 3,000 seconds; default 0 seconds) – Derivative action, gives an immediate control output in response to changes in the proportional output with time (derivative). The amount of increase or decrease depends on the rate of change of the error. The rate constant (D) allows the user to adjust the amount derivative control contributes to the control signal. Smaller values reduce the effect of deriva-tive control.
- Mode: Mode has two settings, Auto (Automatic) and Man (Manual). In the Auto mode the control output is controlled automatically by the PID algorithm. In manual mode, the control output can be set to a constant value; this is useful during transmitter calibration or servicing.
- Value (Manual) (range: 0 100%) – When the Manual mode is chosen; this control ap-pears on the screen and allows you to write the constant control output value in the Manual mode.
- Select Next to open the final PID control window.

7.2.4 Transport time

Transport Time makes it possible to apply PID control action to a process flowing in a pipe for a short period of time (run time), and then hold the control output fixed to allow the treated sample time to mix and travel to the pH or other analytical sensor (transport time). If properly tuned the PV should reach the setpoint after successive time periods.

It is best used when raw sample pH (or concentration) remains relatively steady for long periods of time, as is the case for samples flowing from a large body of water. It should not be used where process upsets are possible because the delay in applying control will make recovery from the upset slow, and can result in overshoot after the incoming sample has returned to a normal range.



Transport Time Parameters: Basic Definitions

- Transport Time (On/Off) – Turns the Transport Time feature on or off.
- Transport Time (range 1 to 600 seconds) – When Transport Time is turned On; a control appears at the right of it, which allows the value of the Transport Time to be enter. This will be the time period that PID control output is held constant, while the treated sample travels to the sensor.
- Run Time (range 0 to 60 seconds) – This is the time period that PID control action is automatic. It always must be a shorter time than Transport Time.

Fault: Basic Definitions

1. Fault – When a measurement fault occurs (either sensor or transmitter) the control output can be setup to continue providing a live control output or the output can be set to a fixed value. If the live reading is used during a fault condition, the control output could be based on an erroneous measurement, which might cause problems. Using a fixed value for control output during a fault condition can ensure that the control output goes to an acceptable value.
2. Fault Current – If a fixed value on fault is chosen, this parameter selects the output. The control output on fault can be set to a value to prevent a major upset or an unsafe condition.

Note
If a fixed fault current output is chosen and PID control Mode is set to Manual, the Manual output value will override the Fault Current value.

---

8 Time proportional control

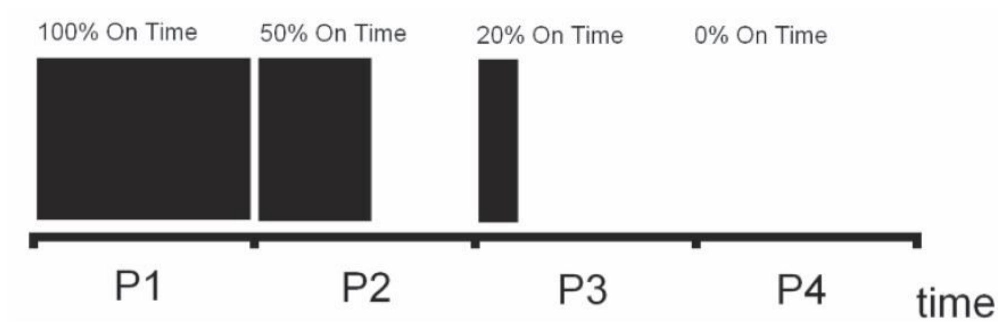
8.1 Introduction

8.1.1 Time Proportional Control

Time Proportional Control is more commonly known as Duty Cycle or Pulse Width Modulation. It applies PID control to the activation of a relay rather than using an analog output.

The TPC output is defined as the percent of time that a relay is on (% On Time), during a user selected time period (Time Period). As the control output increases the on time increases:

Figure 8-1: TPC periods and on time



The proportional, integral, and derivative are defined the same as analog PID control, but use % On Time instead of % Output:

Proportional On Time ( ) = [Gain × (PV – SP) x 100 / (URV – LRV)] + BIAS

Proportional and Integral Control:

On Time = [Gain × 100 / (URV – LRV)] + [(PV – SP) + 1/I (PVt – SP) Δt]

Derivative Mode:

On Time = [Gain × 100 / (URV – LRV)] × D × [(PVt – SP) – (PVt-1 – SP)] / Δt

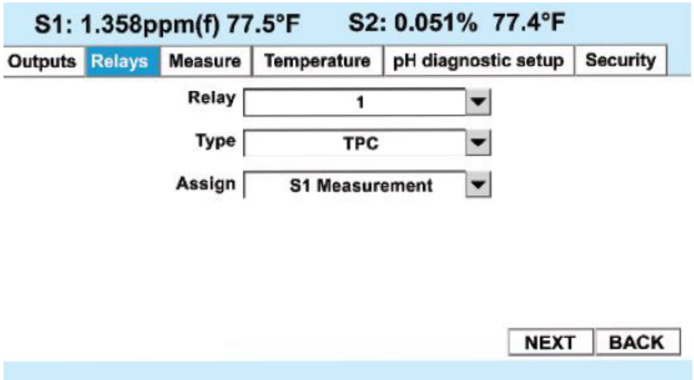
As with analog PID control, TPC can be direct acting (URV > LRV) or reverse acting (LRV > URV). For more detail see Section 7.1, PID Control Introduction.

8.1.2 TPC setup

Selecting TPC

Procedure

Select TPC control, the relay to be used, and the measurement to be controlled from the main relay setup window:



Basic Definitions

- Relay – Select the relay (1 through 4) to be use for TPC control.
- Type – Choose TPC.
- Assign – Select the Measurement to be controlled.

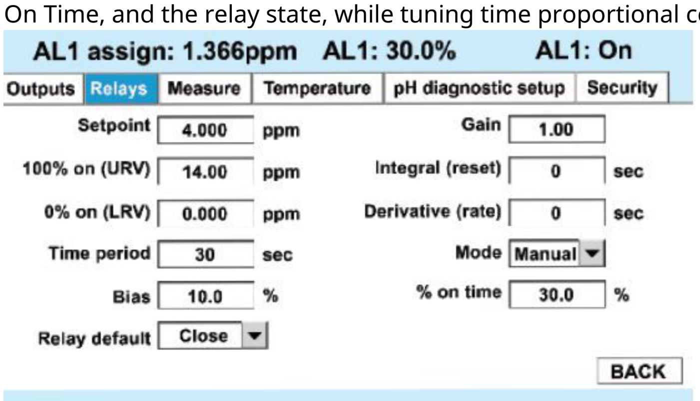
Note
This measurement can also be a 4-20 mA signal input brought in by the flow/ 4-20 mA board.

- Select **Next** to go to the PID Setup parameters.

TPC Setup Parameters

The TPC setup window contains the PID control tuning parameters.

Additionally, note that the upper portion of the screen shows the relay number and the value of the measurement assigned to it, the % On Time for the relay, and the current state of the relay, i.e. On or Off. This makes it possible to observe the primary variable (PV), the % On Time, and the relay state, while tuning time proportional control.



PID Control Parameters: Basic Definitions

- Setpoint – Select the desired setpoint.
- URV – The value of PV (in the above example, 14.00 pH) at which the control will be 100% On Time.
- LRV – The value of PV (in the above example 0.00 pH) at which the control will be 0% On Time.

Note
If you want the control output to increase as PV (in this case pH) increases, URV should be greater than LRV. This is direct acting control action. Examples of direct acting control are the addition of acid to decrease pH and adding water to a solution to decrease the concentration.

If you want the control output to decrease as PV increases, i.e. reverse acting control action, the URV should be less than LRV. Examples of reverse acting control are adding caustic to increase pH and adding a concentrated solution to water to make a solution of lower concentration.

- Time Period (range: 10 to 3,000 seconds; default 30) – The time period for each cycle of TPC.
- Bias (range: 0 to 100%; default 0%) – Bias is a fixed control output which allows the % on time to be greater than zero when the measurement (PV) is at setpoint. It is used in proportional only control to prevent cycling resulting from the % on time going to zero at the setpoint.
- Relay default (Close, Open, None) – Select the relay action during a fault condition.
- Gain (range: 0.0 to 1000.0; default 0.0) – In proportional (P) only control, the output is directly proportional to the difference between the process variable (PV) and the setpoint divided by the output span (URV – LRV). Gain is a factor which multiplies the proportional output to meet the requirements of the process being controlled. Using Gain values less than 1 reduce the proportional output while Gain values greater than 1 increase the proportional output.
- Integral (Reset, I) (range: 0 to 3,000 seconds; default 0 seconds) – Integral repeats the proportional action in a time period given by the reset time (I). The reset time is given in seconds per repeat and is adjustable from 0 to 3,000 seconds. Integral control acts as an automatic bias which increases or decreases the overall control output in response to the error (PV – SP) to keep the PV at the setpoint.
- Derivative (Rate, D) (range: 0 to 3,000 seconds; default 0 seconds) – Derivative action, gives an immediate control output in response to changes in the proportional output with time (derivative). The amount of increase or decrease depends on the rate of change of the error. The rate constant (D) allows the user to adjust the amount derivative control contributes to the control signal. Smaller values reduce the effect of derivative control.
- Mode: Mode has two settings, Auto (Automatic) and Man (Manual). In the Auto mode the control output is controlled automatically by the PID algorithm. In manual mode, the control output can be set to a constant value; this is useful during transmitter calibration or servicing.
- On Time (Manual) (range: 0 100%) – When the Manual mode is chosen, this control ap-pears on the screen and allows you to write the constant On Time value in the Manual mode.

9 Alarm relay functions

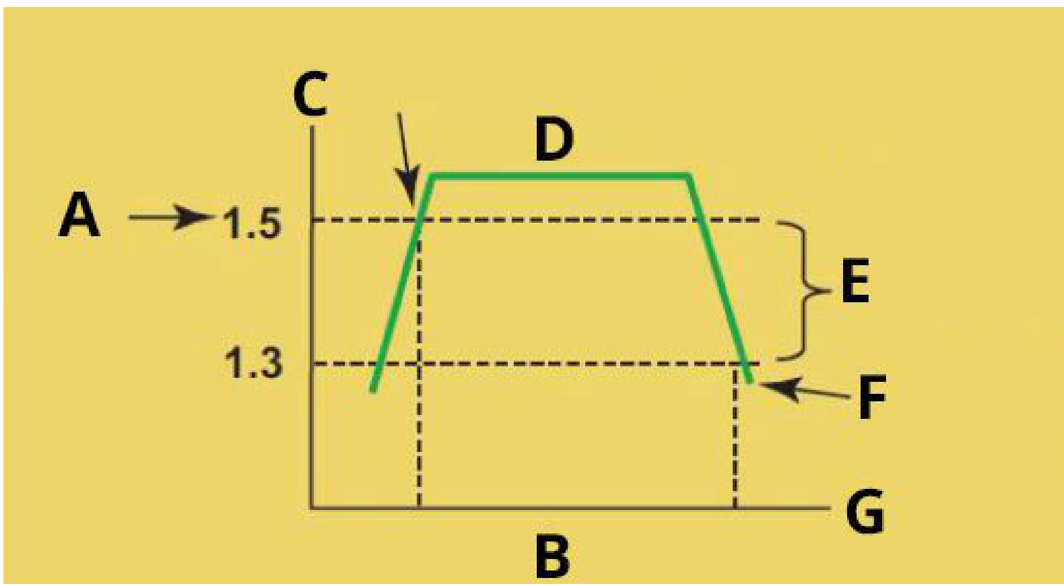
9.1 High/Low concentration alarm

9.1.1 Description

High/Low concentration alarms are setpoint alarms with adjustable deadband. These operate as simple on/off alarms used for applications requiring discrete on/ off control of pumps and valves. Typical applications include demineralizer bed regeneration and blowdown in boilers and cooling towers. Any active device variable in the Rosemount 56 Transmitter can be programmed as a high/low concentration alarm including the primary or secondary variables, temperature, raw values and diagnostics.

The following schematic describes the high/low concentration (setpoint) alarm operation:

Figure 9-1: High/Low Concentration Alarm Operation



- A. *High alarm setpoint*
- B. *High alarm logic*
- C. *PV*
- D. *Alarm activates*
- E. *Deadband (0.2)*
- F. *Alarm deactivates*
- G. *Time*

9.1.2 Set up High/Low Concentration alarm

Access high/low concentration (setpoint) alarms by pressing **ENTER/MENU** from the main screen and then **Program** → **Relays** → **Configure Relay**. From the main relay programming screen, program this feature as follows:

Procedure

1. Relay: Assign a relay by highlighting the desired relay 1-4 and press **ENTER/ MENU**.
2. Type: Select Setpoint as the relay type and press **ENTER/MENU**.
3. Assign: Assign S1 (sensor 1), S2 (sensor 2 if available), or other available parameters to the designated relay and press **ENTER/MENU**.
4. Logic: Set High for a high setpoint or Low for a low setpoint and press **ENTER/ MENU**.
5. Setpoint: Enter the desired setpoints value. Press **ENTER/MENU**.
6. Deadband: To set deadband as a measurement value, enter the change in the process value needed after the relay deactivates to return to normal (and thereby preventing repeated alarm activation). Press **ENTER/MENU**.
7. Select **NEXT**. Press **ENTER/MENU** to advance to the next setup screen.
8. Normal state: Set the normal alarm condition as Open or Closed and press **ENTER/ MENU**. Program the normal state to define the desired alarm default state to normally open or normally closed upon power up.

Table 9-1: Defaults and Programmable Limits

Relay function	Limits and selections	Default
Setpoint	NA	NA
Logic	Low/High	High
Setpoint	(1)	(1)
Deadband	(1)	0.000
On time	0 to 999.9 min	0 min
Delay time	0 to 999.9 min	0 min
Normal state	Close/Open	Open

(1) *See Appendix 1 – HART and Device Variables*

9.2 Delay Timer

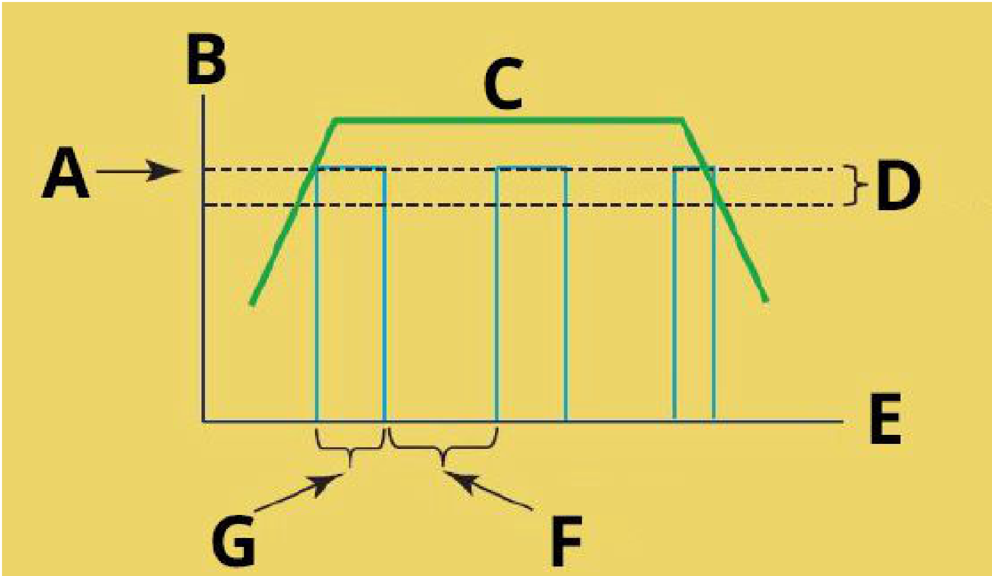
9.2.1 Description

Delay Timer is a concentration control scheme which delays live measurement after chemical addition using (one or all four) of the Rosemount 56 alarm relays. This ensures sufficient mixing time in a vessel or recirculation loop before live sensor measurement, preventing unmixed readings that might cause overshooting. Relay On time and Delay times are field-programmable. Typical applications that would utilize the Delay Timer are:

- Concentration control in vessels
- pH adjustments for neutralization
- Endpoint control for oxidation reduction reactions

A schematic of the Delay Timer operation is shown:

Figure 9-2: Delay Timer Alarm Operation



A. *High alarm setpoint*
B. *PV*
C. *Measurement*
D. *Deadband*
E. *Time*
F. *On time*
G. *Delay time*

9.2.2 Set up Delay Timer

Access Delay Timer by pressing **ENTER/MENU** from the main screen and then **Program** → **Relays** → **Configure Relay**. From the main relay programming screen, program this feature as follows:

Procedure

1. Relay: Assign a relay by highlighting the desired relay 1-4 and press **ENTER/MENU**.
2. Type: Select Delay Timer as the relay type and press **ENTER/MENU**.
3. Assign: Assign S1 (sensor 1), S2 (sensor 2 if available), or other available parameters to the designated relay and press **ENTER/MENU**.
4. Logic: Set High for high reading setpoint logic or Low relay logic for low reading setpoint logic and press **ENTER/MENU**.
5. Setpoint: Enter the desired setpoints value. This will activate an alarm event when the process measurement reaches the entered setpoint value. Press **ENTER/MENU**. See Table 9-3.
6. Deadband: To set deadband as a measurement value, enter the change in the process value needed after the relay deactivates to return to normal (and thereby preventing repeated alarm activation). Press **ENTER/MENU**.
7. Select **NEXT**. Press **ENTER/MENU** to advance to the next setup screen.
8. On time: Enter the time in minutes (X.X min) for the relay to remain energized.

The assigned measurement value will be on hold during this time.

9. Delay time: Enter the time in minutes (X.X min) to take the assigned measurement off hold after the relay is re-energized to begin reporting live values.
10. Normal state: Set the normal alarm condition as Open or Closed and press **ENTER/ MENU**. Program the normal state to define the desired alarm default state to normally open or normally closed upon power up.

Table 9-2: Defaults and Programmable Limits

Relay functions	Limits and selections	Default
Delay timer	NA	NA
Logic	Low/High	High
Setpoint	(1)	(1)
Deadband	(1)	0.000
Normal state	Close/Open	Open

(1) See Appendix 1 – HART and Device Variables.

9.3 Bleed and Feed timer

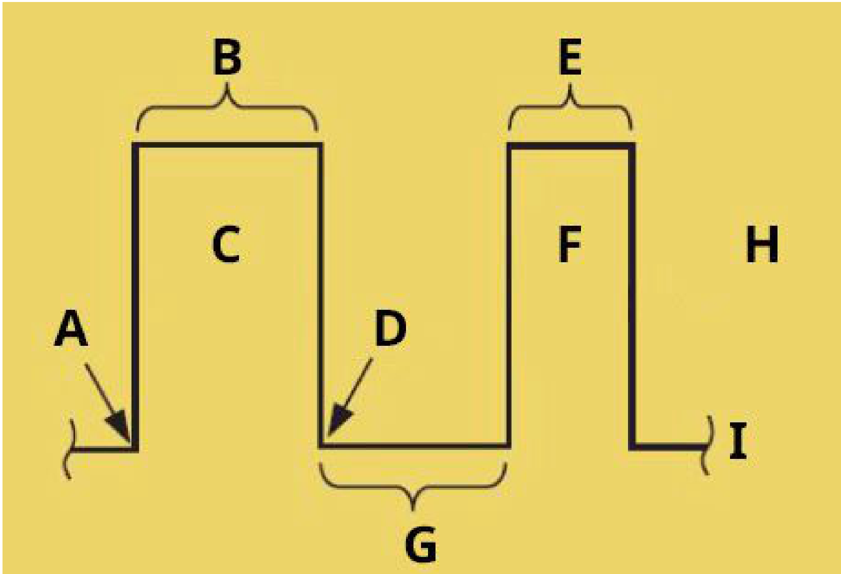
9.3.1 Description

A Bleed and Feed timer is typically used to replace chemicals lost during blowdown. It involves two or more relays. The bleed relay is a normal setpoint alarm relay. Once the bleed relay deactivates, one or more feed relays activate for a percentage of the time the bleed relay was on.

Bleed and Feed timers support continuous monitoring of blow-down water conductivity to determine the point of excessive conductivity. At a programmable maximum concentration value, dumping (bleeding) of the excessively dirty blow-down water is triggered. Subsequently, pumping (feeding) of additional make-up water chemicals is enabled to account for lost blow-down water. Through level control, make-up water is added in proportion to the volume of blowdown material lost through dumping and evaporation.

A schematic of the Bleed and Feed timer operation is shown:

Figure 9-3: Bleed and Feed timer alarm operation



- *A. On*
- *B. Bleed on*
- *C. AL1 (bleed)*
- *D. Off*
- *E. Feed on*
- *F. AL2 (feed)*
- *G. Delay*
- *H. Feed time = X% of bleed time*
- *I. Time*

9.3.2 Set up Bleed and Feed Timers

Access Bleed and Feed Timers by pressing **ENTER/MENU** from the main screen and then **Program** → **Relays** → **Configure Relay**. From the main relay programming screen, program this feature as follows:

Procedure

1. Relay: Assign relay 1 for Bleed and Feed and press **ENTER/MENU**.
2. Type: Select Bleed and Feed as the relay type and press **ENTER/MENU**.
3. Assign: Assign S1 (sensor 1), S2 (sensor 2 if available), or other available parameters to the designated relay and press **ENTER/MENU**.
4. Logic: Set High for high setpoint or Low for low setpoint and press **ENTER/ MENU**.
5. Setpoint: Enter the desired setpoints value. This will activate an alarm event when the process measurement reaches the entered setpoint value. Press **ENTER/MENU**. See Table 9-2.
6. Select **NEXT**. Press **ENTER/MENU** to advance to the next setup screen.
7. Deadband: To set deadband as a measurement value, enter the change in the process value needed after the relay deactivates to return to normal (and thereby preventing re-peated alarm activation). Press **ENTER/MENU**.

8. Normal state: Set the normal alarm condition as Open or Closed and press **ENTER/ MENU**. Program the normal state to define the desired alarm default state to normally open or normally closed upon power up.
9. Select **NEXT**. Press **ENTER/MENU** to advance to the next setup screen: ***Configure feed relay***.
10. Feed relay: Assign relay 2, 3, or 4 as a feed relay and press **ENTER/MENU**.
11. Linked to bleed relay: No entry required. The relay originally programmed as the Bleed relay is displayed.
12. Delay time: Enter the time in minutes (X.X min) after the Bleed time is activated before triggering this feed relay.
13. Feed time equals: Enter the percent of time that the Bleed timer is on (X.X%) to activate this feed relay (for pumping make-up water chemicals).

Relay function	Limits and selections	Default
Bleed and feed	NA	NA
Logic	Low/High	High
Setpoint	(1)	(1)
Deadband	(1)	0.000
Normal state	Close/Open	Open
Feed relay	1, 2, 3, 4	Not assigned
Linked to bleed relay	1, 2, 3, 4	1
Delay time	0 - 999.9 min	1.0 min
Feed time equals	0 - 999.9% bleed time	10.0% of bleed time
Normal state	Close/Open	Open

(1) See Appendix 1 – HART and Device Variables.

9.4 Totalizer Based Relay Activation

9.4.1 Description

A totalizer based timer feeds chemicals for a preset period every time a programmed volume of liquid has been added to or removed from a vessel. The relay energizes when the volume has been reached and remains energized for a fixed time. The process repeats once the volume has been reached again.

Totalizer Based Relay Activation triggers a relay at user-defined intervals based on accumulated totalized flow. The scheme uses pulse inputs from a flow meter or 4-20 mA current input(s) from a flow transmitter to calculate total flow (as volume).

A typical application for totalized flow relay activation is controlling chemical dosing in reactors. A schematic of the Totalizer timer operation is shown: