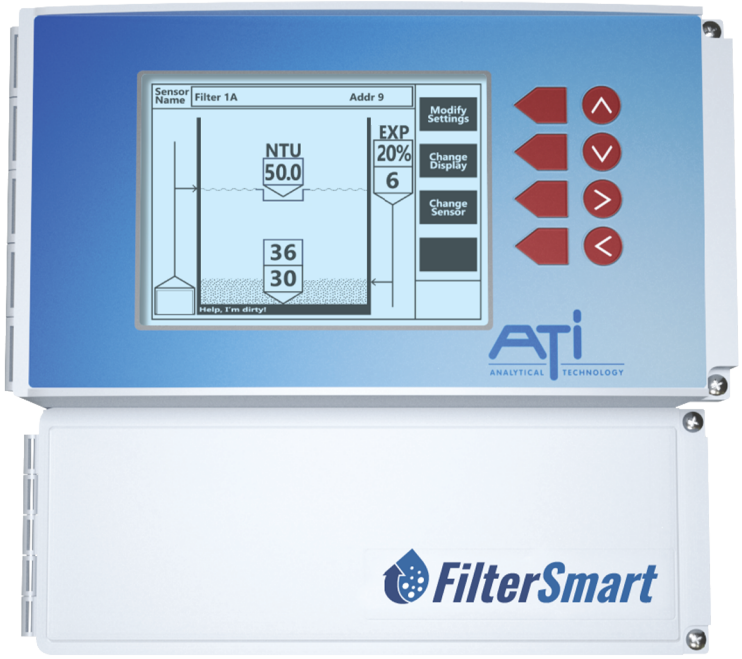
A Badger Meter® Brand

Water Quality Monitor

FilterSmart Backwash Monitor



Badger Meter

ATI-UM-04429-EN-02 (July 2025)

User Manual

CONTENTS

Safety Precautions 7
About this Manual 7
User's Responsibility for Safety 7
Wiring and Electrical 7
Proper Installation and Handling 8
Material Compatibility 8
Product Description 9
Stand-Alone Instrument Option 9
Field Network Option 9
Network Integrated to Customer Data Acquisition and Controls 9
Applications 10
Drinking Water and Wastewater Treatment Filters 10
Tertiary Filters in Wastewater Treatment 10
Granular Media Pressure Filter 10
FilterSmart Sensor (FSS) 11
Sensor Overview 11
Sensor Specifications 11
FilterSmart Controller (FSC) 12
Controller Overview 12
Operator Interface Overview 12
Keypad 13
Navigation Keys 13
Specifications and Connections 14
Controller Specifications 14
Controller Connections 15
Initializing and Configuring Controller and Smart Sensor(s) 16
Initial Controller Setup Screen 16
First Time Controller and Sensor System Installation 17
Replacing a Controller with Existing Sensor(s) 18
Using Informational Screens 18

Filter View Screen 19
Echo Profile Screen 19
Sensor Register Screens 20
Modify Settings Screen 21
Controller Setup Screen 22
Advanced Settings Screen 23
Sensor Selection Menu 24
Automatic Initialization and Reboot Sensor 24
Returning Sensor to Default Settings 24
FilterSmart Power Supply Unit (FSP) 25
Specifications and Connections 25
Power Supply Unit Specifications 25
Power Supply Connections 25
Installation of Equipment 27
Installation of FilterSmart Sensor 27
Stationary Objects in Path of Transmit Pulse 27
Areas of Excessive Air/Gas Bubbles and Turbulence 27
Installation of FilterSmart Controller and Power Supply Unit 27
Filter Configuration, Waveform Analysis and Tracking 31
Filter Configuration 31
Waveform Analysis 32
Signal Waveform Symbols 32
Communications, Outputs and Networking 33
Configuration of Individual Units and Networks 33
Stand-Alone Instrument 33
Wired RS-485 Field Network 33
Wireless (RF) Field Network 35
Integrated Field Networks 36
Outputs and Communication Options 36
RS-485 Modbus RTU 36
Primary Analog Current Loop 37
Turbidity Analog Current Loop 37
Factory Remote Service 38
Instrument Programming Parameters 39
Modify Settings Parameters 39

Units (in.) 39
Media Depth (36) 39
Wiper Timing (240) 39
Primary 4…20 mA (Media Level) 39
4 mA Set Point (0.0) 39
20 mA Set Point (60.0) 39
Echo Loss (OFF) 39
Echo Delay (60) 40
Echo Loss Action (Cycle) 40
Display Contrast (55) 40
Advanced Settings Parameters 40
Auto Gain (ON) 40
Current Gain (30) 40
Total Measurement Range (Auto Calculated) 40
Sensor Blanking Zone (12.0 inch) 40
Sensor Measurement Limit (Auto Calculated) 40
Level Simulation Test 40
Aux Simulation Test 41
Set Sensor to Default Settings 42
Maintenance and Troubleshooting 43
Preventive Maintenance 43
Sensor Cleaning and Maintenance 43
Other Routine Maintenance 43
Troubleshooting 44
Comm Error Message 44
Echo Loss Message 44
Validating Message 44
Validation Failure Message 44
Wiper Stalled Message 44
Wiper Motor Failure Message 44
Analog Output Discrepancy 45
Sensors Not Detected 45
Radio (RF) Communications 45
Persistent "Acquiring Waveform" Message 45
System Options 46

General Overview 46
Internal Configuration 46
External Configuration 46
Equipment Orientation for Units with Integrated Wireless Radio Modules 47
Relays 48
General Overview 48
Operation 48
Cabling and Connections for Relays 49
Digital (RS-485) to Analog (4…20 mA) Converter 50
Converter Overview 50
Converter Specifications 50
Converter Cabling and Connections 50
Configuring the Converter 51
Analog Outputs 51
Quick Start Guide 52
Configuring a Single Sensor 52
Configuring a Sensor Network 54

SAFETY PRECAUTIONS

About this Manual

PLEASE READ THIS ENTIRE MANUAL PRIOR TO INSTALLING OR USING THIS PRODUCT.

Observe the following safety precautions in the implementation and use of this product.

The FilterSmart Controller (FSC), FilterSmart Power Supply Unit (FSP) and FilterSmart Sensor (FSS) are intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read the operating information carefully before using the product.

User's Responsibility for Safety

Responsible body: this is the individual or group responsible for the use and maintenance of equipment, and for making sure that operators are adequately trained. Operators are to use the product for its intended function. They should not be allowed access to the electrical connections within the control box and would normally only operate the external keypad and monitor the display.

Maintenance personnel perform routine procedures on the product to keep it operating (for example, checking the line voltage or checking electrical connections, replacing main fuses and so on). Only service personnel should perform other tasks.

There are no user-serviceable parts on the main PCB section of the FilterSmart FSC or FSP. Service personnel are trained to work on live circuits and perform safe installations and repairs of products. Only properly trained service personnel may perform installation and service procedures.

Wiring and Electrical

Users of this product must be protected from electric shock at all times. The responsible body must make sure that users are prevented access and/or insulated from every connection point. Product users must be trained to protect themselves from the risk of electric shock.

Before operating an instrument, make sure the line cable is connected to a properly grounded power receptacle. Inspect the connection cables for possible wear, cracks or breaks before each use. When fuses are used in a product, replace with same type and rating for continued protection against fire hazard.

For **CE and safety compliance**, adequate grounding and shielding are required. All FilterSmart system cables are to be installed in metal conduit that is properly grounded and shielded using EMC-compliant methods. Each conduit should be individually shielded and grounded. Where metal enclosures are supplied, each enclosure should be grounded and shielded to each individual conduit.

External chassis components cannot be used as safety earth ground connections.

Standard fuses, with applicable national safety approvals, may be used if the rating and type are the same. If you are unsure about the applicability of a replacement component, call Badger Meter for information. Only use the FilterSmart FSC or FSP with the sensor supplied. Replace Fuse with 1.25A 5 × 20 mm T-Lag UL approved.

This equipment is suitable for use with 110…240V AC power at 50…60 Hz. No internal changes are required within this range. Equipment is optionally available and can be ordered for use with 24V DC power. Caution must be taken to supply main power in the form for which the equipment is designed.

A protective earth should be provided for all installations.

⚠WARNING

IF THIS EQUIPMENT IS USED IN A MANNER NOT SPECIFIED BY BADGER METER, THE PROTECTION PROVIDED MAY BE IMPAIRED. THE FILTERSMART FSC, FSP, AND FSS ARE REGARDED AS PERMANENTLY INSTALLED EQUIPMENT AND AS SUCH A SWITCH OR CIRCUIT BREAKER MUST BE INCLUDED IN THE INSTALLATION. THIS SHOULD BE IN CLOSE PROXIMITY TO THE EQUIPMENT, IT SHOULD BE MARKED AS THE DISCONNECTING DEVICE, AND IT SHOULD DISCONNECT BOTH CURRENT CARRYING CONDUCTORS.

⚠ WARNING

CHECK THAT THE POWER SUPPLY IS SUITABLE BEFORE SWITCHING POWER ON.

Proper Installation and Handling

The normal application for the FilterSmart FSC or FSP requires it to be installed at industrial installations including water and wastewater treatment plants. While the FSC and FSP enclosures are liquid-resistant (IP65), they are not designed to be immersed. These items should be mounted in such a way that the enclosure does not come into contact with the application media under normal operational conditions. The FSS (sensor) and its cabling are designed to be submerged without hazard to the equipment or to operators when correctly connected as described in this manual.

To clean the instrument, use a damp cloth or mild, water-based cleaner. Clean the exterior of the instrument only. Do not apply cleaner to the inside of the instrument or allow liquids to enter or spill on the instrument.

Material Compatibility

The FSC and FSP enclosures are made of flame retardant Polycarbonate (PC/ABS FR). The FSS enclosure is made of epoxy-filled ABS. Some sensor models include additional wetted parts. Make sure that the model you select is chemically compatible with the application media, temperatures and pressures to which it will be exposed.

⚠ WARNING

WHEN APPLICABLE, THIS EQUIPMENT COMPLIES WITH FCC RADIATION EXPOSURE LIMITS SET FORTH FOR AN UNCONTROLLED ENVIRONMENT. THIS EQUIPMENT SHOULD BE INSTALLED AND OPERATED WITH MINIMUM DISTANCE 20 CM BETWEEN THE RADIATOR AND YOUR BODY. THIS TRANSMITTER MUST NOT BE CO-LOCATED OR OPERATING IN CONJUNCTION WITH ANY OTHER ANTENNA OR TRANSMITTER.

PRODUCT DESCRIPTION

FilterSmart™ is an application-specific version of the FilterSmart™ ultrasonic interface level analyzer. Implementations typically employ a sensor that includes a fully integrated scattered light turbidity meter.

The operating system was developed to address the unique measurement requirements of granular media filters during backwash. Primary measurement indications are media level, media expansion in engineering units and as a percentage of expandable media and backwash turbidity in the range of 0.0…50.0 NTU. Together, these measurements provide the essential information necessary for effective backwash control.

FilterSmart can be implemented as individual, stand-alone instruments or with numerous sensors networked together and operated by a single controller.

Stand-Alone Instrument Option

When connected to a FilterSmart Controller, the instrument has all the functionality of a complete measurement system. The controller provides power to the sensor and is the user interface for instrument programming and communication with the sensor. Customer terminations for digital and analog communications to the customer's data acquisition and control system are provided inside the controller.

A large graphical LCD with control keypad provides a simple and intuitive platform to implement sensor parameters, configure communications, view current and historical measurements and perform system diagnostics. HELP PROMPTS automatically display for each parameter and system function.

Field Network Option

A single controller can operate up to 16 FilterSmart Sensors in a wired or wireless Field Network. In either arrangement, the network is fully integrated and requires no software integration by the customer.

The controller handles all programming and monitoring functions for all sensors in the network. Power supply units provide power to associated sensors and are fitted with integrated two-way transmitter modules when used in an RF network. Terminations for analog communication (4…20 mA signal) are also at the power supply unit.

Network Integrated to Customer Data Acquisition and Controls

FilterSmart Field Networks can be integrated to the customer's data acquisition and control system via two-wire RS-485, Modbus RTU protocol. See *"RS-485 Modbus RTU" on page 36* for additional information.

APPLICATIONS

FilterSmart is suitable for most municipal and industrial granular media gravity filters. It may also be used in granular media pressure filters subject to certain mechanical, pressure, physical and installation limitations (Contact Badger Meter technical support for details).

Drinking Water and Wastewater Treatment Filters

FilterSmart instruments are most frequently implemented in granular media gravity filters in drinking water treatment plants to provide the essential information necessary for the effective control of filter backwashing. Media expansion measurements help operators optimize the scrubbing effect of agitated media grains produced by the correct and consistent wash water flow. Turbidity measurements in the top of the filter, during backwash, provide critical information for correcting and fine-tuning wash duration often resulting in dramatic savings of wash water usage and related pumping and manpower cost.

Tertiary Filters in Wastewater Treatment

Cost savings can be equally important in wastewater treatment tertiary filters in plants, especially in cases that treated water is sold for reuse. Uses and benefits are the same as found for drinking water applications.

Granular Media Pressure Filter

As with drinking water and wastewater treatment applications, pressure filters benefit from the effective control of media expansion during backwash. Often considered equally important in these applications is the continuous monitoring of media level (depth of media), since these filters typically remain online for extended periods of time, and there is no way to know whether media has been lost and may be at critically low levels.

Due to physical filter design features and pressure limits, application suitability is subject to special sensor installation arrangements and engineering approval by the factory. Self-cleaning wiper sensors and sensors that include turbidity measurements are generally not suitable in pressurized applications.

FILTERSMART SENSOR (FSS)

The FilterSmart Sensor is a microprocessor controlled piezoelectric transducer designed specifically for operation under water (submerged in the process liquid).

Sensor Overview

The FilterSmart Sensor generates an ultrasonic sound wave that propagates through the filter water above the filter media and is reflected back. The sound wave travels at known velocities, providing the ability to convert elapsed time into media level and expansion measurements. With a known dimension to the bottom of the expandable media, the measurement can be expressed in terms the depth of the filter media, and the amount of expansion during backwash can be calculated both in engineering units and as a percent of the total media depth.

Sensors that include a scattered light turbidity measurement are frequently used. This provides a highly useful additional measurement of backwash turbidity. This measurement is used to assist the operator in determining the optimal filter wash duration.

Sensor Specifications

Power Requirement	15V DC; 3W
Range	1.0…32 ft (0.305…10.0 m)
Sensor Meas. Resolution	0.1 unit of measure
Accuracy *	0.2 in. at 10.0 ft (5 mm at 3.05 m)
Operating Temperature	34…125° F (1…52° C)
Configuration Backup	Settings stored in FLASH memory
Sensor Construction	IP68, ABS and epoxy Stainless steel and rubber (wiper only)
Turbidity	Measurement principle: 90° scattered light, pulsed LED Range: 0…50 NTU Repeatability: 1% @ 50 NTU*
Weight	2.75 lb (1.25 kg)
Certifications	CE

* Accuracy has been tested under controlled conditions using AMCO clear turbidity standards. Field results of ± 2% across the measurement range can be expected with an installation on a properly grounded circuit. Since the sensor is installed in an active filter, turbidity readings can be affected by bubbles, poor electrical grounding, localized flow rate at the sensor and heavier suspended solids that may be present dynamically.

FILTERSMART CONTROLLER (FSC)

The FilterSmart Controller allows for programming and local monitoring of one to sixteen FilterSmart Sensors.

Controller Overview

The controller screen consists of a graphical backlit LCD (2.6 × 3.45 inch viewing area) that is divided into five functional sections. Soft keys and navigation keys located to the right of the screen are used for data entry and other operations. *Figure 1* points out the functional sections of the screen and the location of the soft keys and navigation keys.

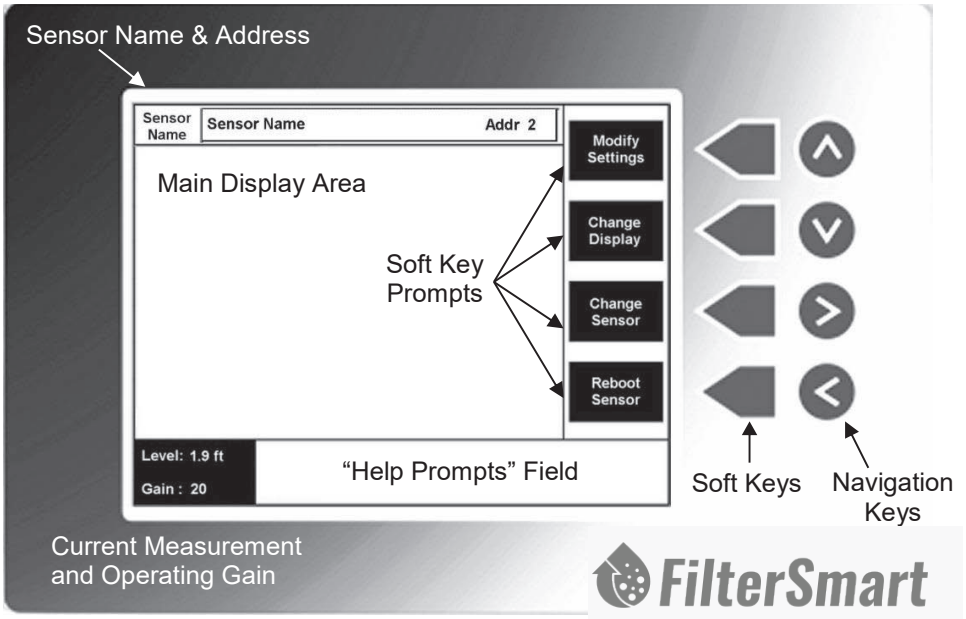


Figure 1: LCD display

Operator Interface Overview

The screen has five informative sections:

- Smart Sensor Name and Address
- Current Measurement and Operating Gain
- Help Prompts Field
- Main Display Area
- Soft Keys

Smart Sensor Name and Address

The bar at the top of the screen shows the name and network address that has been assigned to the sensor. This is the sensor that is currently being interrogated. Information on this and all other screens relates to this sensor.

If the controller is operating a multi-sensor field network, press the **Change Sensor** soft key to see the other sensors. A listing of network sensors appears (see *Figure 18 on page 24*). Use the navigation keys to select the desired sensor and press the **Select Sensor** soft key.

Current Measurement and Operating Gain

The current measurement, operating gain (signal amplification) and turbidity value (when applicable) are conveniently available in the lower left corner of all screens. Additionally, messages regarding external communication (see *"Outputs and Communication Options" on page 36*) taking place and error messages (see *"Troubleshooting" on page 44*) associated with the active sensor screen in this section.

Help Prompts Field

The *Help Prompts Field* across the lower section of each screen provides an explanation of the screen or the highlighted parameter. *Help Prompts* reduce the need for referencing the printed user manual.

Main Display Area

The area has both digital and graphical capabilities. The content changes with the functionality of the selected screen.

Soft Key Prompts

The vertical bar on the right side of the screen consists of four boxes. The text in each box describes the function of the *Soft Key* located next to that box. The text changes when you select a different function or navigate to a different instrument parameter.

Keypad

The FilterSmart Controller has four soft keys and four navigation keys.

Soft Keys

The function of a soft key is described by the *Soft Key Prompt* located immediately to the left of the key. Use the soft keys to change instrument settings, switch to a different screen or trigger other actions.

When using a soft key to increase or decrease a value, hold down the key in order to quickly modify the value.

Navigation Keys

Navigation Keys advance the instrument cursor to the desired location on the screen for operation by soft key commands.

Screen Navigation Overview

An overview of the organizational structure of the screens is shown in *Figure 2*.

NOTE: Functionality for the *Relay Setup* and *Digital-to-Analog Converter Setup* requires purchase of the associated hardware.

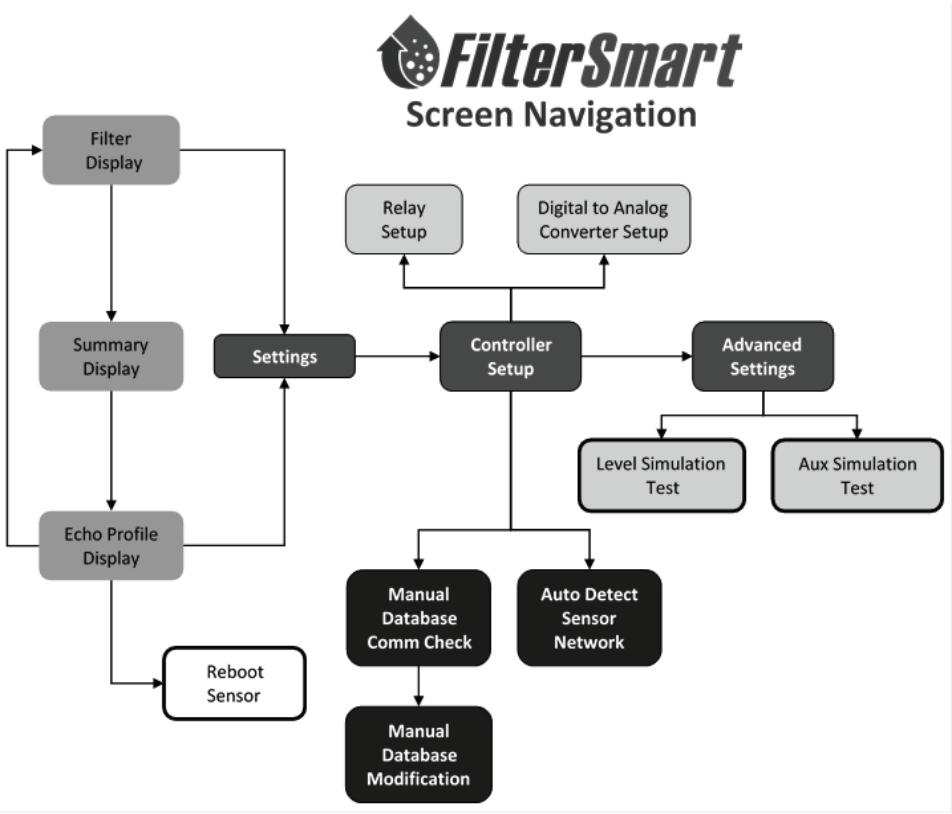


Figure 2: Screen navigation overview

Specifications and Connections

This section pertains to the physical layout of the controller terminal connectors and how they are connected as a stand-alone system. If you want to network the controller with other devices (like FSP or SCADA Systems), see *"Communications, Outputs and Networking" on page 33* for sample connection diagrams.

Controller Specifications

Input Power	100…240V AC, 50/60 Hz – 1.5A, 65W Optional 24V DC: 19…42V DC
Supply Cable	10…18 AWG, – 40…140° F
Fuse	1.25A 250V 5 × 20mm T-lag UL approved fuse
Analog Loops	(2) 4…20 mA Outputs 15…24V DC (provided by FSC for local sensor)
Ambient Temperature	– 40…140° F (– 40…60 °C)
Display	Graphical backlit monochrome screen Resolution: 320 × 240 pixels Viewing Area: 2.6 × 3.45 in. (92 × 122 mm)
Reported Meas. Resolution	1.0 (in. and cm), 0.1 (ft), 0.01 (m)
RF Module (Optional) for Europe	868 MHz frequency band Self-healing mesh network Approvals: CE RED
RF Module (Optional) for North America	900 MHz frequency band Self-healing mesh network Approvals: FCC Part 15C, Industry Canada
Relays (Optional)	(4) Relays: 10A @ 250V AC; 10A @ 30V DC
Enclosure	NEMA 4X, IP65; Polycarbonate
Weight	Approx. 3.0 lb (1.36 kg) depending on configuration
Certifications	CE

IMPORTANT

Delays in data retrieval from multiple sensors can exist because of the unpredictable nature of wireless communication due to interference, distance, obstructions and so on. The wireless field network is therefore not recommended unless the local analog outputs are being used.

⚠CAUTION

SUPPLY MAIN POWER IN THE FORM FOR WHICH THE EQUIPMENT IS DESIGNED.

Controller Connections

- The FSC circuit board contains four screw-terminal connectors as well as additional plug-in connectors (see *Figure 3*). To prevent damage, do not over-tighten the screw terminals.
- Verify the power cable (10…18 AWG) is properly connected to the power connector.
- Install a breaker to fully remove power from the unit in the event that repairs to the unit are required.
- Connect sensors (FSS) to the controller by color (see *Figure 3*).
- The table in *Figure 4 on page 16* contains a functional description of the screw terminal connectors.

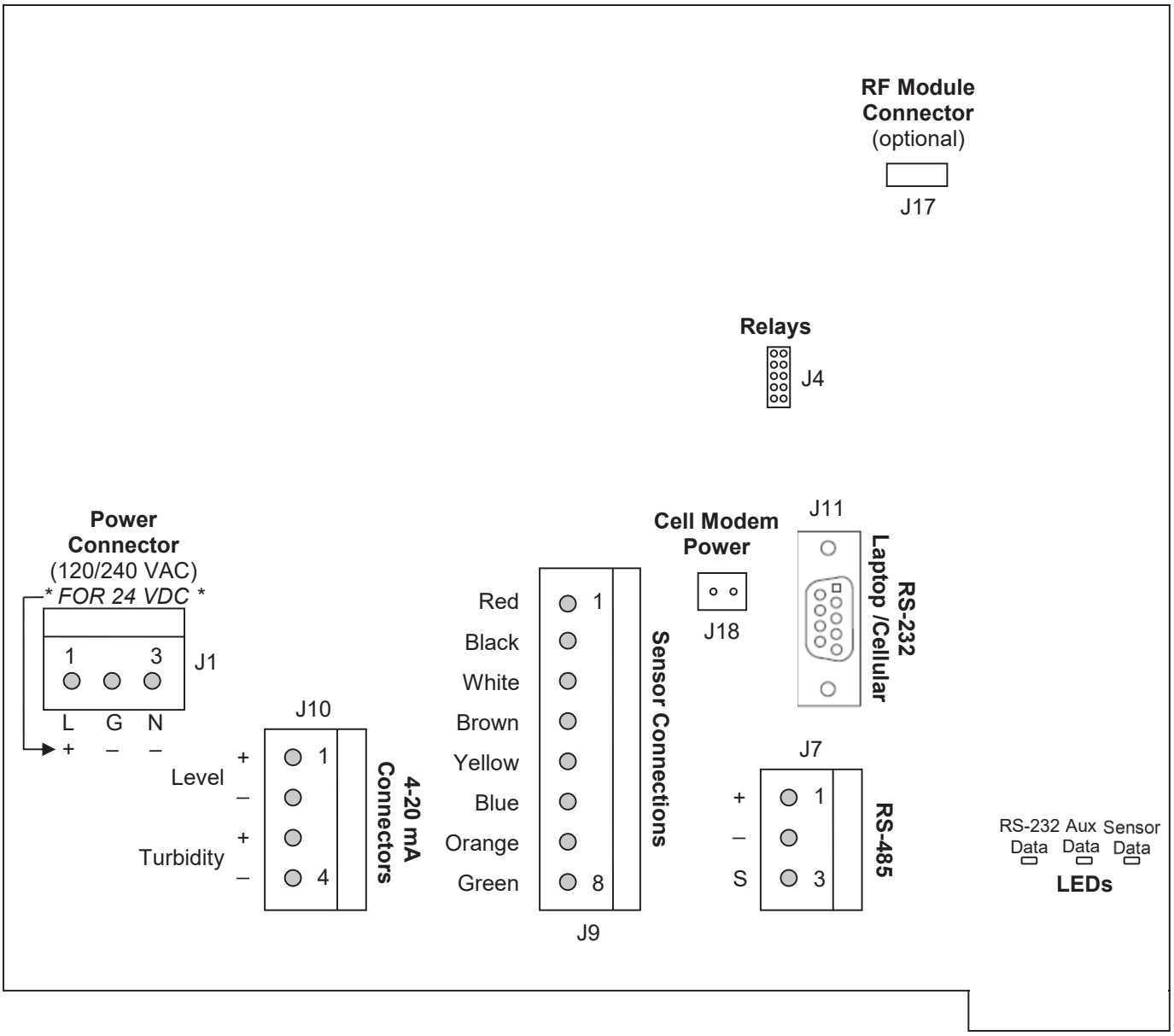


Figure 3: Controller connections

Power Connector (J1) for 100…240V AC		4…20 Analog Connectors (J10)		Sensor Connections (J9)		RS-485 Connector (J7)	
Pin	Description	Pin	Description	Pin	Description	Pin	Description
1	Live	1	Level +	1	15V	1	Sensor Comm
2	Ground	2	Level –	2	Ground	2	Sensor Comm
3	Neutral	3	Turbidity +	3	Sensor Comm (+)	3	Ground
		4	Turbidity –	4	Sensor Comm (–)		
(J1) for 24V DC				5	4…20 mA Level		
1	+			6	4…20 mA Level		
2	–			7	4…20 mA Turbidity		
3	–			8	4…20 mA Turbidity		

Figure 4: Table of controller connections

NOTE: Sensor Connector (J9): Use Pin 3 and Pin 4 to link the Sensor Communication cable from the controller to the next power supply unit in a Wired RS-485 Field Network. Conductors are ganged with those from the sensor. Connection at the associated power supply unit is at the RS-485 Connector (J8).

NOTE: RS-485 Connector (J7): Use this connector when integrating a Field Network to the customer data acquisition and control system. This is the communication link between the controller and an outside device. It is not used to interconnect controllers and power supply units.

NOTE: 4…20 mA current loops are internally powered, grounded and galvanically isolated.

Initializing and Configuring Controller and Smart Sensor(s)

IMPORTANT

Disconnect any outside RS-485 device prior to initiating Controller Setup to avoid communication errors.

Initial Controller Setup Screen

The *Initial Controller Setup* screen (see *Figure 5 on page 17*) appears when power is applied to a controller with an empty sensor register.

FilterSmart instruments employ Smart Sensor technology and are often implemented with multiple sensors operating in union with one controller. To establish communication, you must assign a unique address to each Smart Sensor during initialization (see also *"First Time Controller and Sensor System Installation" on page 17*). The assigned address is held in the memory of both the controller and the Smart Sensor(s).

IMPORTANT

All Smart Sensors are shipped from the factory with the pre-assigned address of 01. In multiple sensor network installations it is imperative that you add sensors to the network one at a time. See "First Time Controller and Sensor System Installation" on page 17. Change the address of each sensor to a unique number from 2…240. Initialize the sensor that is directly connected to the controller first. Power and initialize additional sensors one at a time, carefully noting the individual filter with its corresponding sensor name and address.

Enter the *Current Date* and *Time* at this screen using the navigation and soft keys.

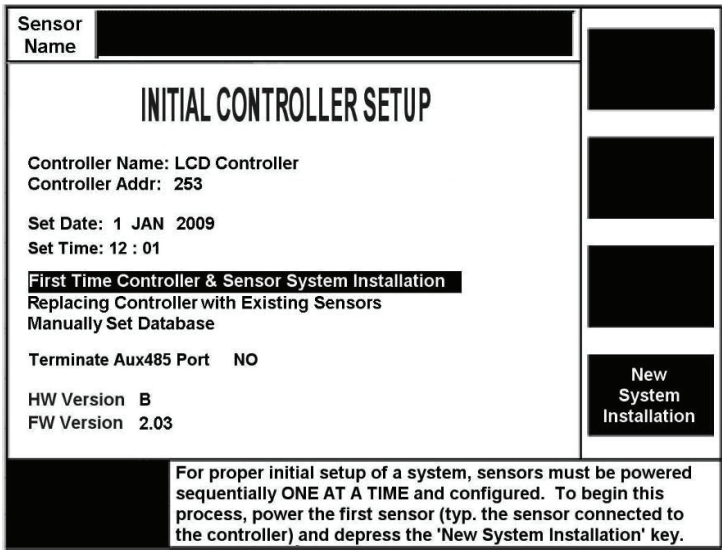


Figure 5: Initial controller setup

First Time Controller and Sensor System Installation

If this is a new installation, select **First Time Controller & Sensor System Installation** and press the **New System Installation** soft key (see *Figure 5*). The controller automatically locates the Smart Sensor that has been powered (this takes a few seconds) and opens the *Initial Sensor Setup* screen (see *Figure 6*).

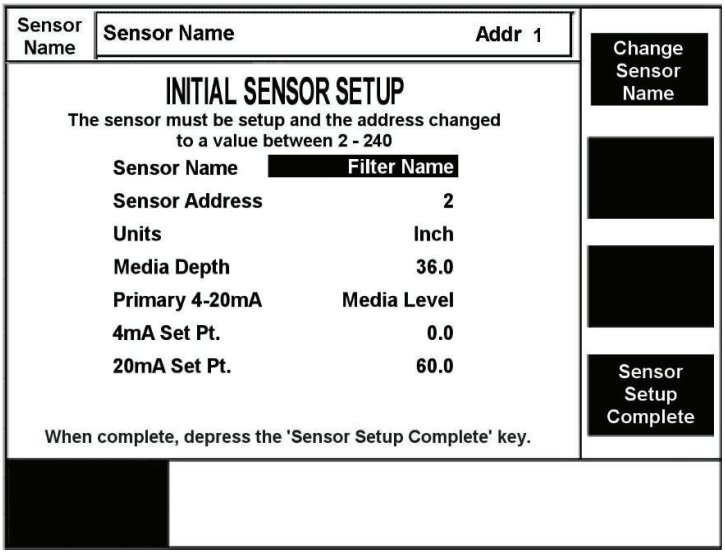


Figure 6: Initial sensor setup

Follow the soft key prompts and use the navigation keys to enter the *Sensor Name* and *Sensor Address*.

IMPORTANT

You must change the Sensor Address from 01 to any unrepeated number from 2…240 before initializing the next sensor in a network.

⚠CAUTION

ALL SENSORS ARE SUPPLIED FROM THE FACTORY WITH THE SENSOR ADDRESS SET AT 01. YOU MUST ASSIGN A UNIQUE ADDRESS TO EACH SENSOR AS YOU ADD IT TO THE NETWORK (POWERED ON). THIS PROCEDURE ALLOWS THE CONTROLLER TO ESTABLISH COMMUNICATION AND PROVIDE A UNIQUE ADDRESS FOR EACH SENSOR. FAILURE TO FOLLOW THIS PROCEDURE WILL RESULT IN MULTIPLE SENSORS HAVING THE SAME ADDRESS AND WILL PREVENT COMMUNICATION.

Press the **Sensor Setup Complete** soft key to finalize setup of the sensor. The *Power Next Sensor* screen (*Figure 7*) appears. Apply power to the FilterSmart Power Supply Unit connected to the next sensor and repeat these steps.

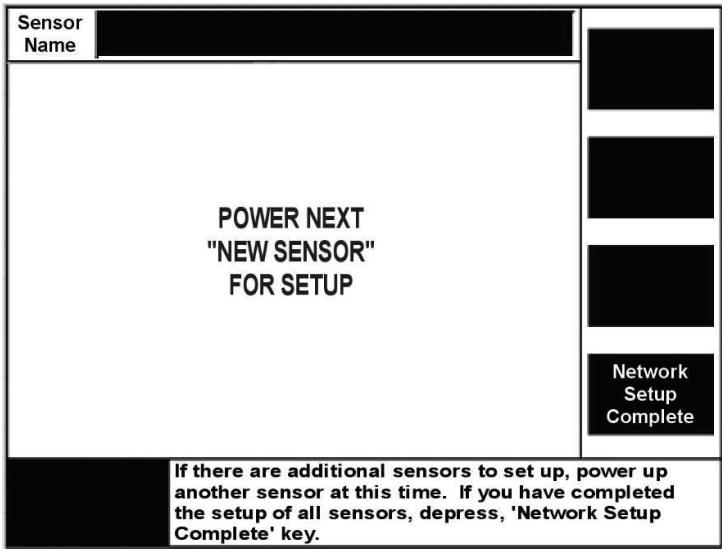


Figure 7: Power next sensor

After all sensors have been initialized, press the **Network Setup Complete** soft key (see *Figure 7*). The controller begins to poll all the FilterSmart Sensors and display current measurements.

See *"Quick Start Guide" on page 52* for step-by-step instructions on configuring a single sensor or a network of sensors.

Replacing a Controller with Existing Sensor(s)

If Smart Sensors have previously been initialized and the controller is being replaced, select *Replacing Controller with Existing Sensors* and press the **Replace Controller Only** soft key. The controller automatically detects the existing sensors and returns to full operation after the initialization routine is completed.

Using Informational Screens

The controller has these informational screens:

- *Filter View* screen
- *Echo Profile* screen
- *Sensor Register* screens (multiple sensor networks only).

Press the **Change Display** soft key to make a selection. At power up, the system defaults to the *Filter View* screen.

There are also screens for entering instrument settings:

- *Modify Settings* screen
- *Advanced Settings* screen
- *Controller Setup* screen

Filter View Screen

The *Filter View* screen (*Figure 8*) shows a scaled cross-sectional view of the filter. The displayed measurements are:

- A – Calculated expansion percentage
- B – Amount of expansion (in selected engineering units)
- C – Current turbidity
- D – Current media depth (Note: Media Depth is established and maintained from user-entered depth at initialization of the instrument)
- E – User-entered media depth

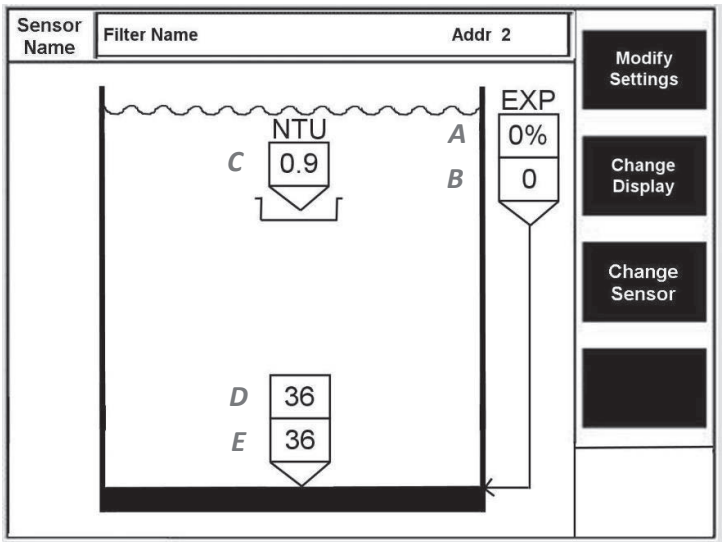


Figure 8: Filter view screen

Echo Profile Screen

The *Echo Profile* screen (*Figure 9*) shows the echo waveform generated by the selected sensor. To view the waveform of another sensor, press the **Change Sensor** soft key, select the desired sensor from the dropdown list and press the **Select Sensor** soft key**.**

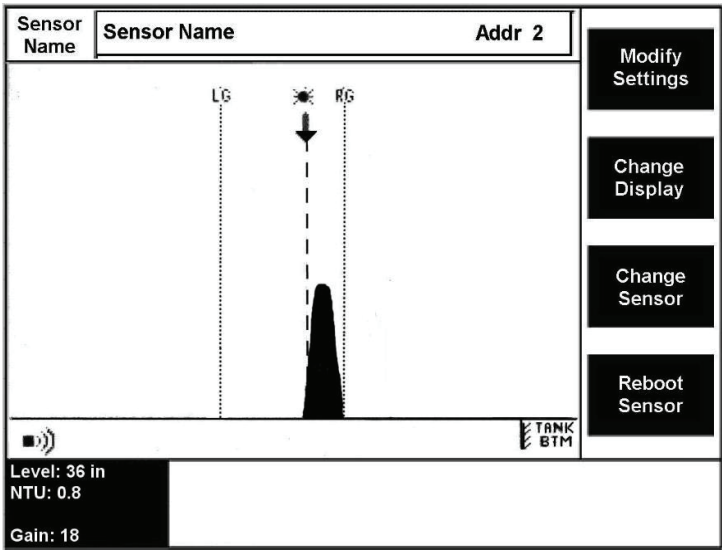


Figure 9: Echo profile screen

This screen presents the actively updated signal waveform generated by the sensor that is used to determine the media level.

The horizontal x-axis is a distance axis based on the span between the sensor (lower, left side of the screen) and the bottom of the expandable media (lower, right side of the screen). The vertical y-axis corresponds to the strength of signal at locations between the sensor and the tank bottom. FilterSmart proprietary interpretive algorithms are applied to the signal waveform to determine the position of the expandable media.

Sensor Register Screens

This screen consists of a table that shows the name of each sensor and its *Current Measurement* and *Operating Gain* value. If the controller is communicating with four or fewer sensors, information is presented as shown in *Figure 10*.

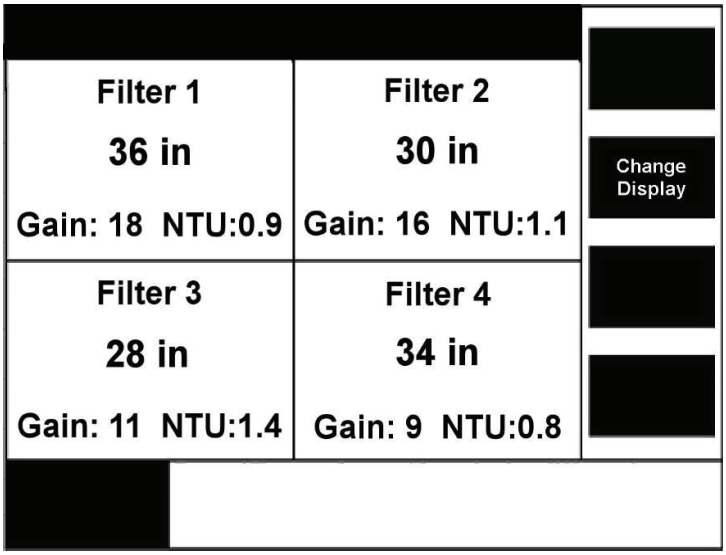


Figure 10: Four sensor field network screen

With five or more sensors, information is presented as shown in *Figure 11*.

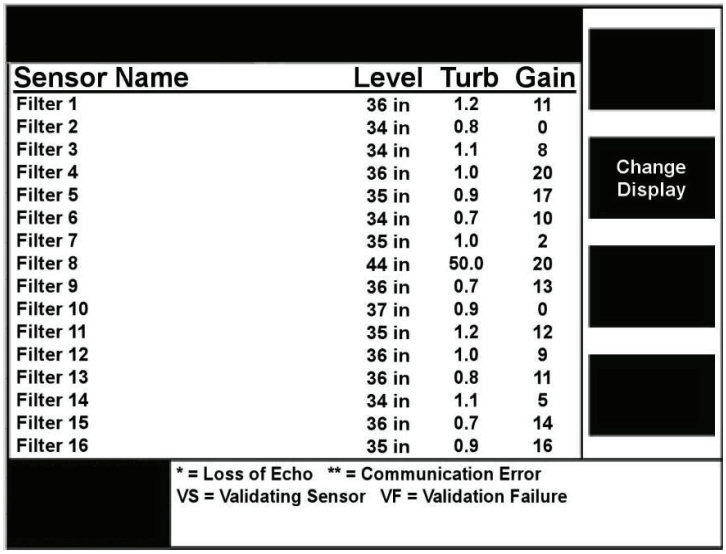


Figure 11: Multiple sensor field network screen

These screens are not available when only one sensor is in use.

Modify Settings Screen

This screen (*Figure 12*) is used to enter the primary parameter settings for each sensor. A *Display Contrast* adjustment function is also found here.

Changes are implemented when you enter them and exit the screen. No confirming command is required.

Descriptions of parameter functions are in *"Instrument Programming Parameters" on page 39*.

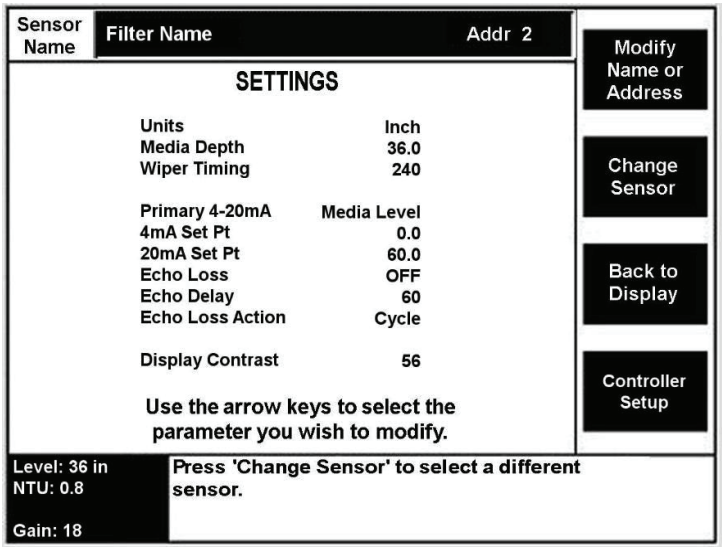


Figure 12: Modify settings screen

To assign a unique alphanumeric name and change its identifier address, press the **Modify Name or Address** soft key (see *Figure 13*).

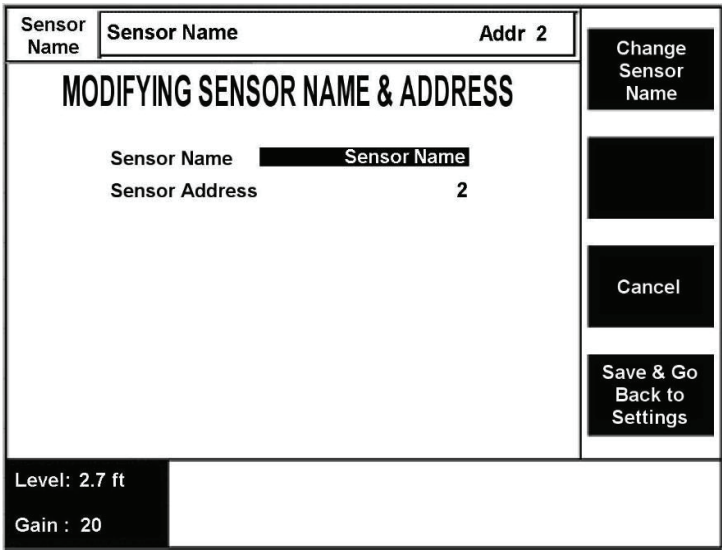


Figure 13: Modifying sensor name and address screen

When modifying the sensor name, use the navigation keys to scroll to selected letters, numbers and symbols to enter the desired sensor name. The soft keys assist with other functions, as indicated by the soft key prompts.

Controller Setup Screen

Use this screen (*Figure 14*) to change the *Current Date* and *Time* and to initiate either a manual or automatic establishment of the sensor network. Actual hardware and firmware versions display on the setup screen.

Setup screens for the optional relays and optional *Digital-to-Analog Converter* are available from this screen. The functionality of these options requires the purchase of the associated hardware.

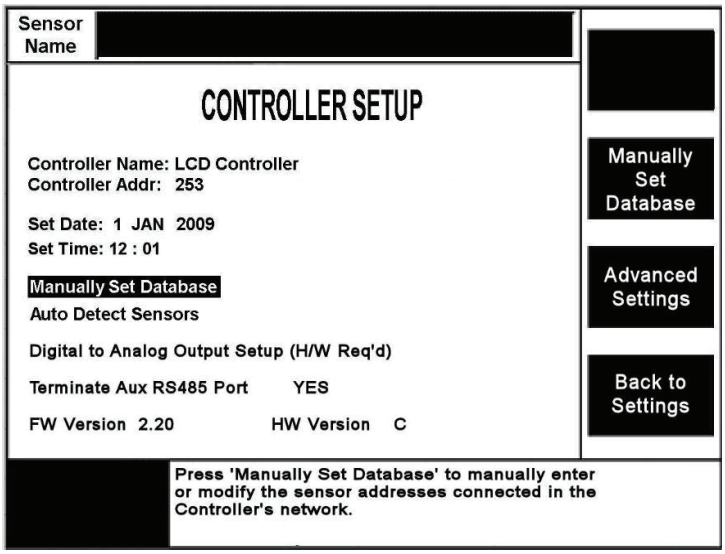


Figure 14: Controller setup screen

Auto Detect Sensors begins a search for sensors that are directly connected to the controller and are part of a field network of sensors. Use this option to initialize a new instrument and to add sensors from an existing network.

Manually Set Database (see *Figure 15*) allows you to specify sensor addresses and establishes the order in which the addresses appear in the *Sensor Register* screen. Manually setting the database causes the controller to persist in attempts to detect listed sensors in cases where *Auto Detect* has failed to locate all sensors.

Select **Manually Set Database** to perform a quick check of the network sensors. When communication is verified, "OK" is displayed next to the sensor address. If communication cannot be verified, "??" displays next to the address.

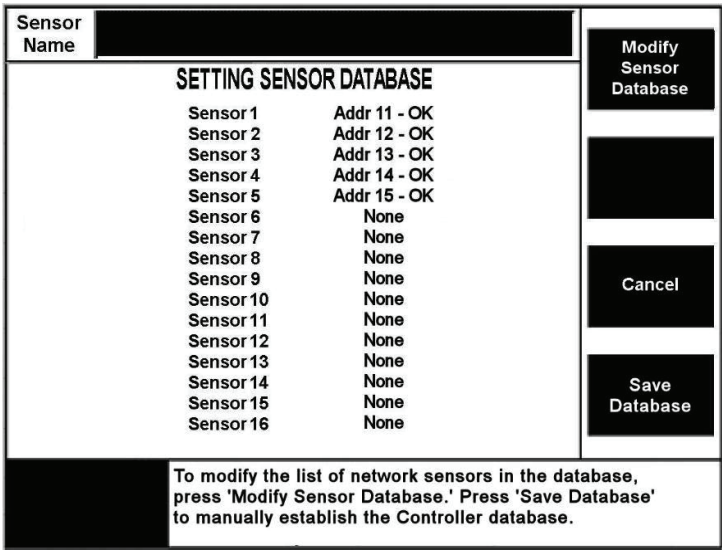


Figure 15: Sensor database screen

To perform modifications to the database, select **Modify Sensor Database**. From the *Modifying Sensor Database* screen (see *Figure 16 on page 23*), you can change network addresses, modify the sensor display order and delete a sensor.

IMPORTANT

Changes made from this menu are ONLY used to modify the existing network of sensor addresses to be polled by the controller and DOES NOT change the sensor's address. Any changes to the sensor address parameter contained in the sensor must be performed from the Modifying Sensor Name and Address screen (see "Sensor Register Screens" on page 20).

When the changes are complete, press the **Done** soft key to return to the *Sensor Database* screen. Press the **Save Database** soft key for the modifications to take effect.

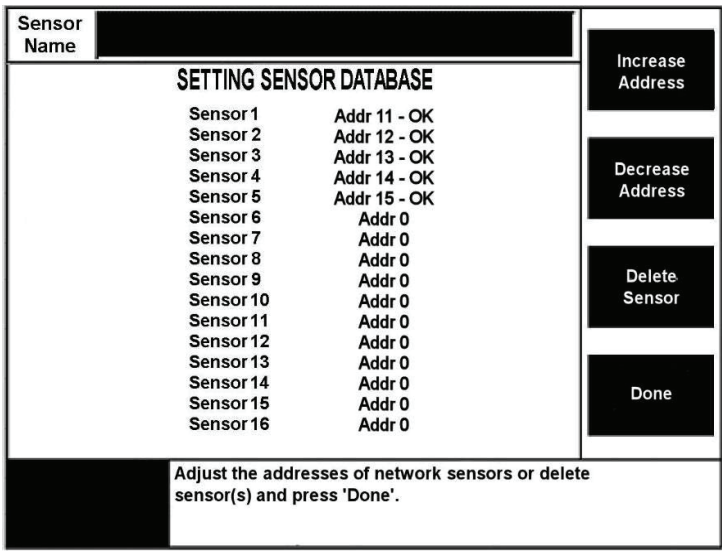


Figure 16: Modifying sensor database screen

After you initiate either the *Auto Detect Sensors* or the *Manually Set Database* command, the *Help Prompt* field (lower right portion of display area) reports the number of sensors found followed by the number of sensors validated. The display then redirects to the display screen and begins polling all the sensors in the database.

To access the *Controller Setup* screen, navigate to the *Settings* screen and press the **Controller Setup** soft key.

Advanced Settings Screen

Use the *Advanced Settings* screen (see *Figure 17*) to enter additional parameter settings for each sensor. Do not change these settings without instruction from Badger Meter or a representative.

To access the *Advanced Settings* screen, press the **Controller Setup** soft key.

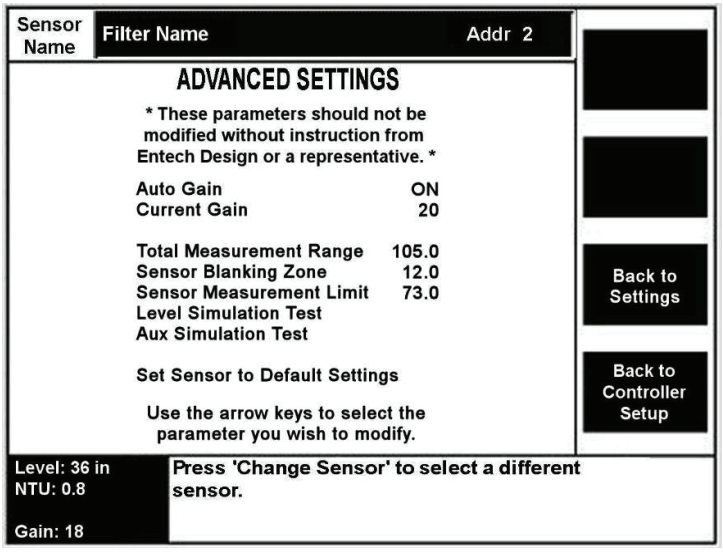


Figure 17: Advanced settings

See *"Instrument Programming Parameters" on page 39* for display descriptions of parameter functions

Sensor Selection Menu

To change the sensor that the controller is currently displaying, press the **Change Sensor** soft key. Use the navigation keys to move to the desired sensor and press the **Select Sensor** key.

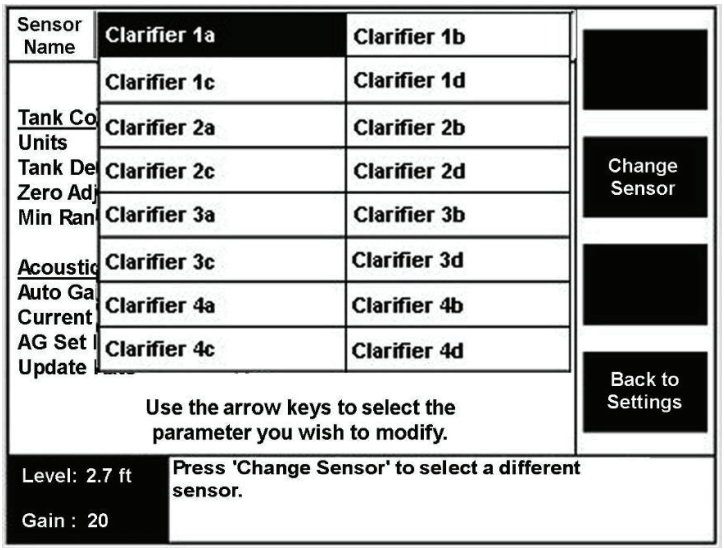


Figure 18: Sensor selection drop-down window

Automatic Initialization and Reboot Sensor

FilterSmart performs automatic initialization and calibration whenever you apply power to the sensor or select the **Reboot Sensor** command from the *Echo Profile* screen. Instrument settings are not lost as a result of power interruption.

Automatic initialization establishes operating gain (signal amplification) and determines current measurement values and signal outputs.

Returning Sensor to Default Settings

If a sensor has been relocated or repositioned in a filter, return all of the sensor settings to default values.

1. From the *Advanced Settings* screen (see *Figure 17 on page 23*), select **Set Sensor to Default Settings**. A warning appears to confirm this action.
2. Once confirmed, the *Initial Sensor Setup* screen (see *Figure 6 on page 17*) appears so you can easily modify the critical parameters.
3. Select **Sensor Setup Complete** to initiate the automatic initialization and calibration routine.

FILTERSMART POWER SUPPLY UNIT (FSP)

The FilterSmart Power Supply Unit provides power to a FilterSmart Sensor and acts as a communication hub to facilitate analog, digital and wireless RF communications from a FilterSmart Sensor.

FilterSmart Power Supply Units do not have display monitors or data entry keypads. They are typically used in a Field Network arrangement in which an FilterSmart Controller provides the user interface function for setting up and monitoring FilterSmart Sensors. See *"Communications, Outputs and Networking" on page 33*.

Specifications and Connections

This section describes the physical layout of the FSP terminal connectors and how to implement them. If you want to network the FSP with other devices (like FSC, other FSPs, SCADA Systems and so on), see *"Communications, Outputs and Networking" on page 33* for sample connection diagrams.

Power Supply Unit Specifications

Input Power	100…240V AC, 50/60 Hz, 1A, 20W Optional 24V DC: 18…36V DC
Supply Cable	10…18 AWG, – 40…140° F
Fuse	0.250A, 250V 5 × 20 mm T-lag UL approved fuse
Analog Loops	15…24V DC (provided by FSP for local sensor) (2) 4…20 mA Outputs
Ambient Temperature	– 40…140° F (– 40…60° C)
RF Module (Optional) for Europe	868 MHz frequency band Self-healing mesh network Approvals: CE RED
RF Module (Optional) for North America	900 MHz frequency band Self-healing mesh network Approvals: FCC Part 15C, Industry Canada
Enclosure	NEMA 4X, IP65; Polycarbonate
Weight	Approx. 1.5 lb (0.68 kg)
Certifications	CE

IMPORTANT

Delays in data retrieval from multiple sensors can exist because of the unpredictable nature of wireless communication due to interference, distance, obstructions and so on. The wireless field network is therefore not recommended unless the local analog outputs are being used.

Make sure you supply main power in the form for which the equipment is designed.

Power Supply Connections

The FSP circuit board contains four screw-terminal connectors as well as additional plug-in connectors. See *Figure 19 on page 26*. Use caution in tightening the screw terminals to prevent damage from over-tightening.

Make sure the power cable (10…18 AWG) is connected to the power connector properly. Connect sensors (FSS) to the power supply by color code. See *Figure 19 on page 26*. See *Figure 20 on page 26* for a functional description of the screw-terminal connectors.

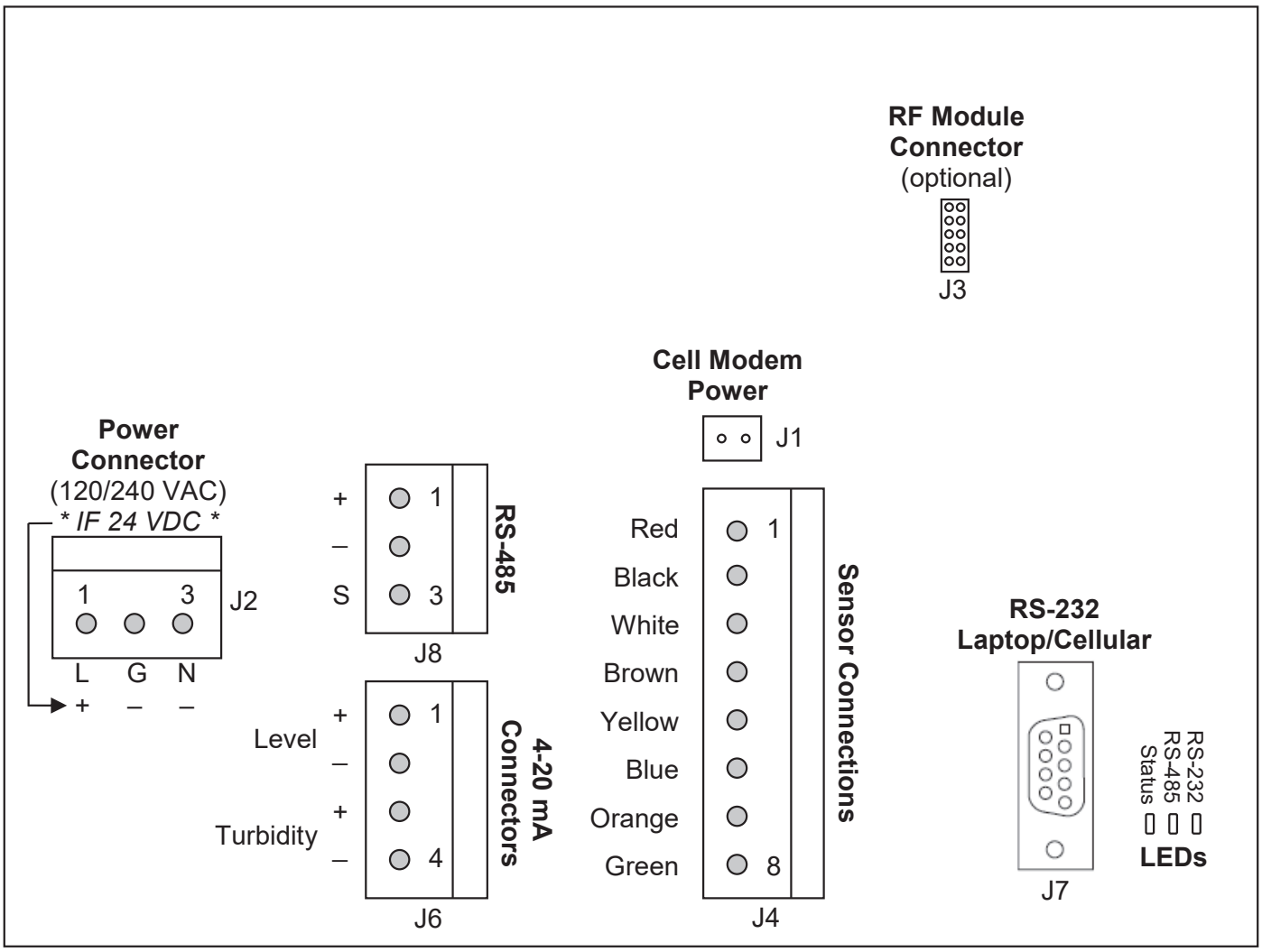


Figure 19: Connections for power supply

Power Connector (J2) for 100…240V AC		4…20 Analog Connectors (J6)		Sensor Connections (J4)		RS-485 Connector (J8)	
Pin	Description	Pin	Description	Pin	Description	Pin	Description
1	Live	1	Level +	1	15V	1	Sensor Comm
2	Ground	2	Level –	2	Ground	2	Sensor Comm
3	Neutral	3	Turbidity +	3	Sensor Comm (+)	3	Ground
		4	Turbidity –	4	Sensor Comm (–)		
(J2) for 24V DC				5	4…20 mA Level		
1	+			6	4…20 mA Level		
2	–			7	4…20 mA Turbidity		
3	–			8	4…20 mA Turbidity		

Figure 20: Table of power supply connections

NOTE: RS-485 Connector (J8): Attach the network communication cable from the controller or power supply unit in a wired RS-485 Field Network to this connector.
Connect the controller at Pin 3 and Pin 4 of the sensor connector (J9).

NOTE: 4…20 mA current loops are internally powered, grounded and galvanically isolated.

INSTALLATION OF EQUIPMENT

Installation of FilterSmart Sensor

Mount the sensor so that the face of the sensor is slightly below the TOP of the wash trough. See *Figure 21 on page 28*. Locate the sensor about 6 inches from the trough, as water flowing into the trough during backwash has more velocity and helps keep the sensor face clear of bubbles or debris. Locating the face of the sensor slightly below the top of the trough maximizes the freeboard, or distance from the sensor face to the static media, and provides maximum measurement range for the sensor (there is a 12-inch blanking zone extending from the sensor face). Locating the sensor face close to the top of the trough also provides a more real-time measurement of the turbidity of the water as it leaves the filter.

Avoid locating the sensor close to the filter wall, as the filter wall can affect the behavior of the expanded media and there is the possibility of the sensor picking up irregularities or structural elements on the filter wall. If possible, locate the sensor where there is an overhang, keeping in mind the guidance above. If no overhang is available or accessible, consider using longer mounting brackets to locate the sensor farther out from the filter wall.

It is normal for the sensor to be above the water during air-scour or surface wash. During these times, the sensor holds its last media level measurement until the water level rises and starts to enter the trough (the turbidity measurement continues when the sensor is out of the water, but it is simply measuring the turbidity of air). At this time, the sensor resumes tracking of both the media level and the turbidity of the water.

Stationary Objects in Path of Transmit Pulse

Do not locate the sensor immediately above piping, filter structural elements, or other objects that encroach on the signal trajectory. Continuously moving surface wash arms typically do not interfere with measurements but should be avoided when possible.

Areas of Excessive Air/Gas Bubbles and Turbulence

Avoid locating the sensor in areas where there are high concentrations of air/gas bubbles Air from air-scouring that is discontinued prior to high rate wash is typically not a problem. FilterSmart is generally NOT appropriate for filters with continuous air-scouring due to excessive air bubbles in the filter during times that are critical for reliable measurements.

Installation of FilterSmart Controller and Power Supply Unit

The FilterSmart Controller and FilterSmart Power Supply Unit are designed for indoor and outdoor installation and are typically attached to safety railing or other structure.

Typically, locate the controller or power supply unit within 20.0 feet of the sensor, as illustrated in *Figure 22 on page 29* and *Figure 23 on page 30*. Sensor cables may be extended at water-tight junction boxes using manufacturer-specified cables or by special order of sensors with continuous cable of longer lengths.

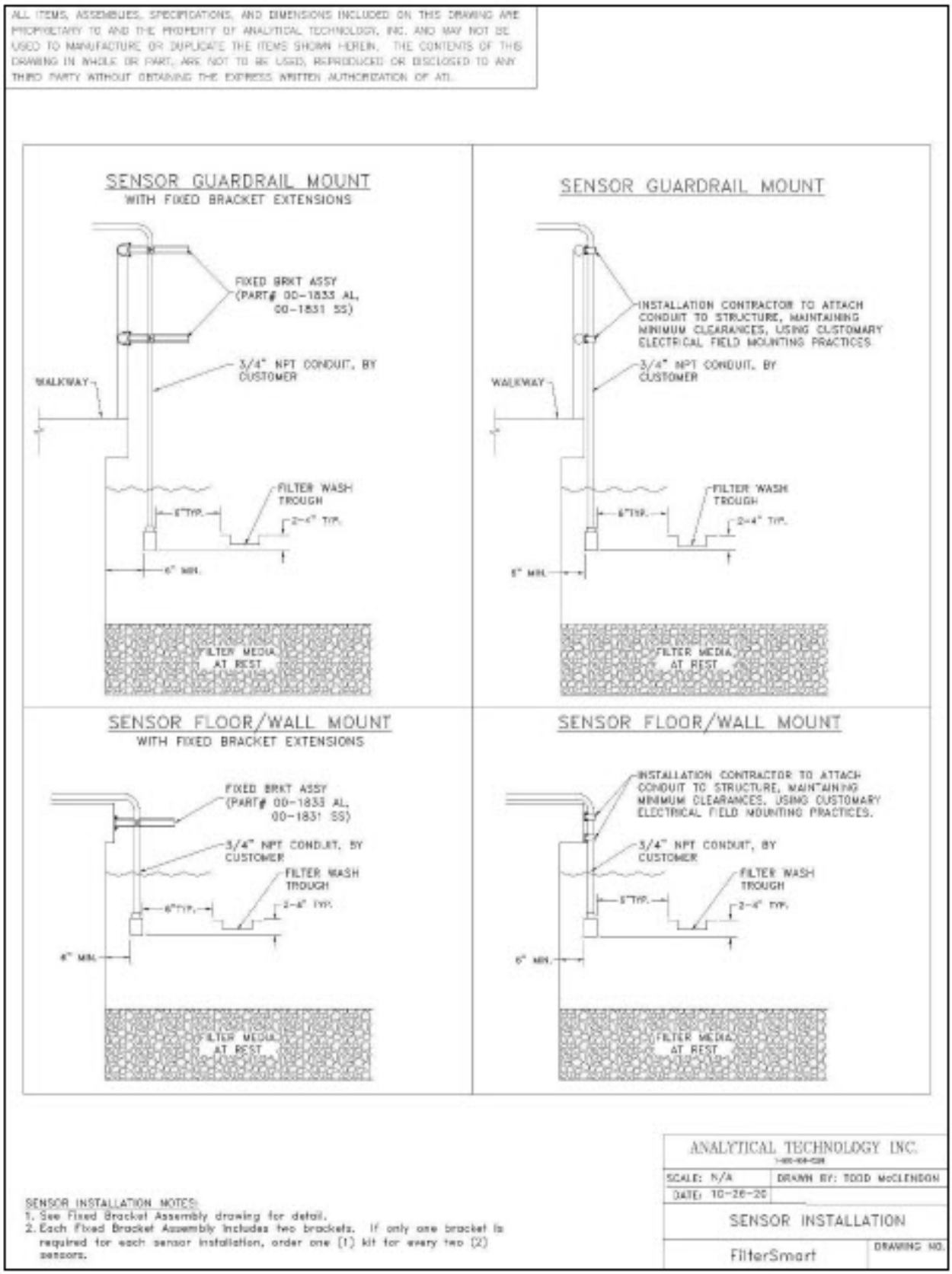


Figure 21: FilterSmart sensor installation arrangements

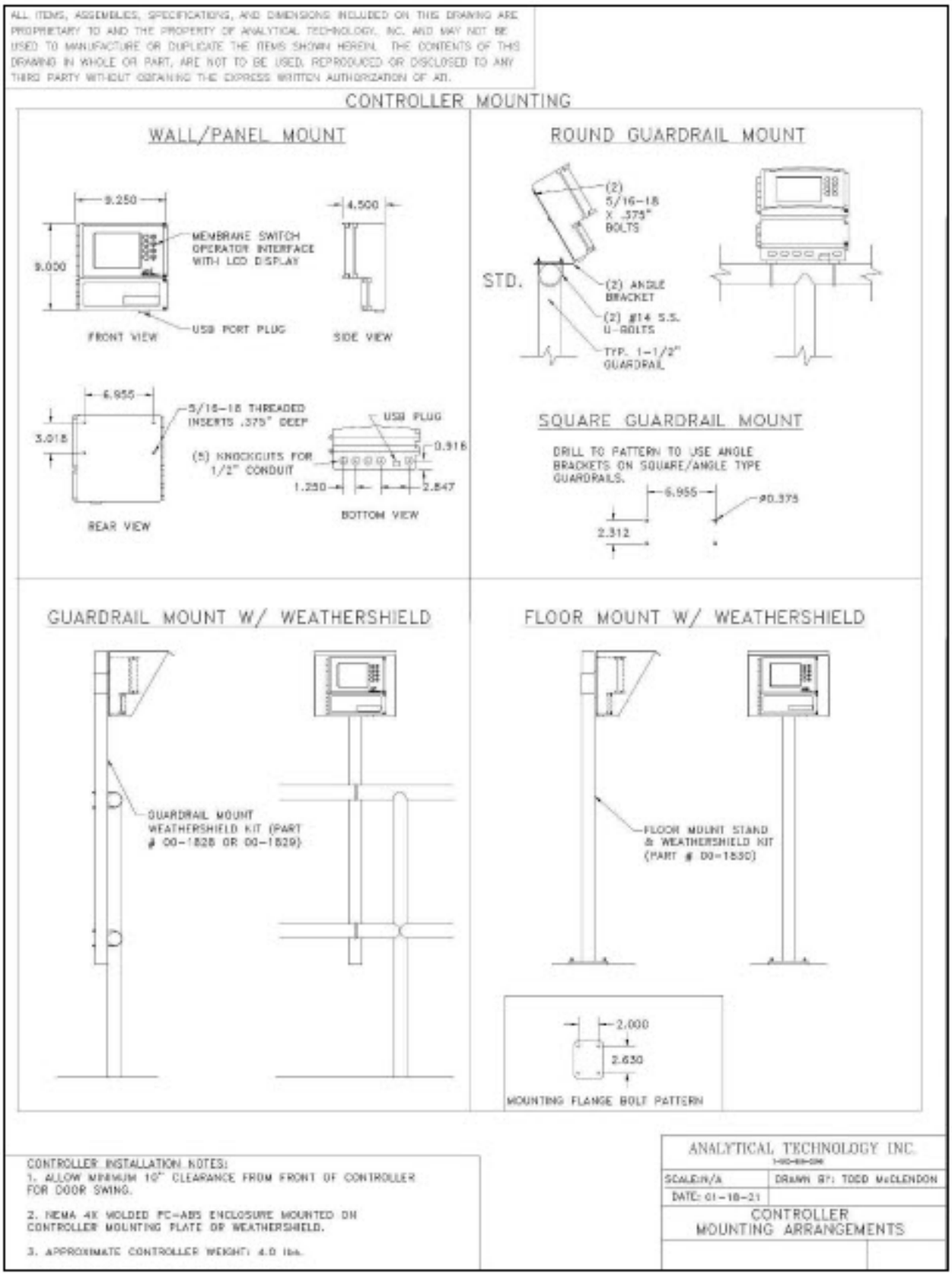


Figure 22: FilterSmart controller installation

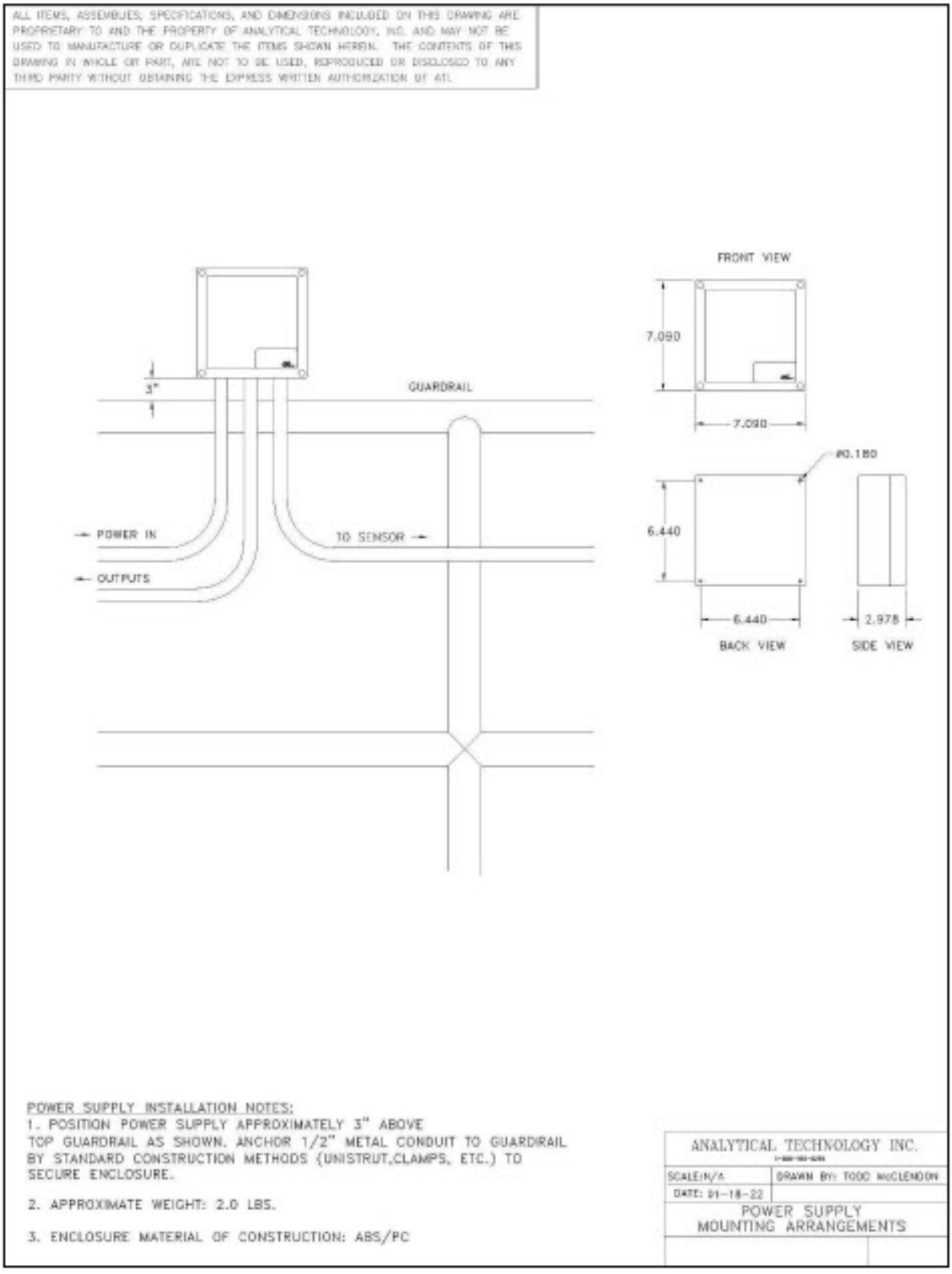


Figure 23: Power supply unit installation

FILTER CONFIGURATION, WAVEFORM ANALYSIS AND TRACKING

FilterSmart applies advanced proprietary echo waveform analysis and filtering routines to provide reliable and repeatable measurements. For proper operation, make sure the instrument settings match the dimensions of the tank in which you install the sensor.

Filter Configuration

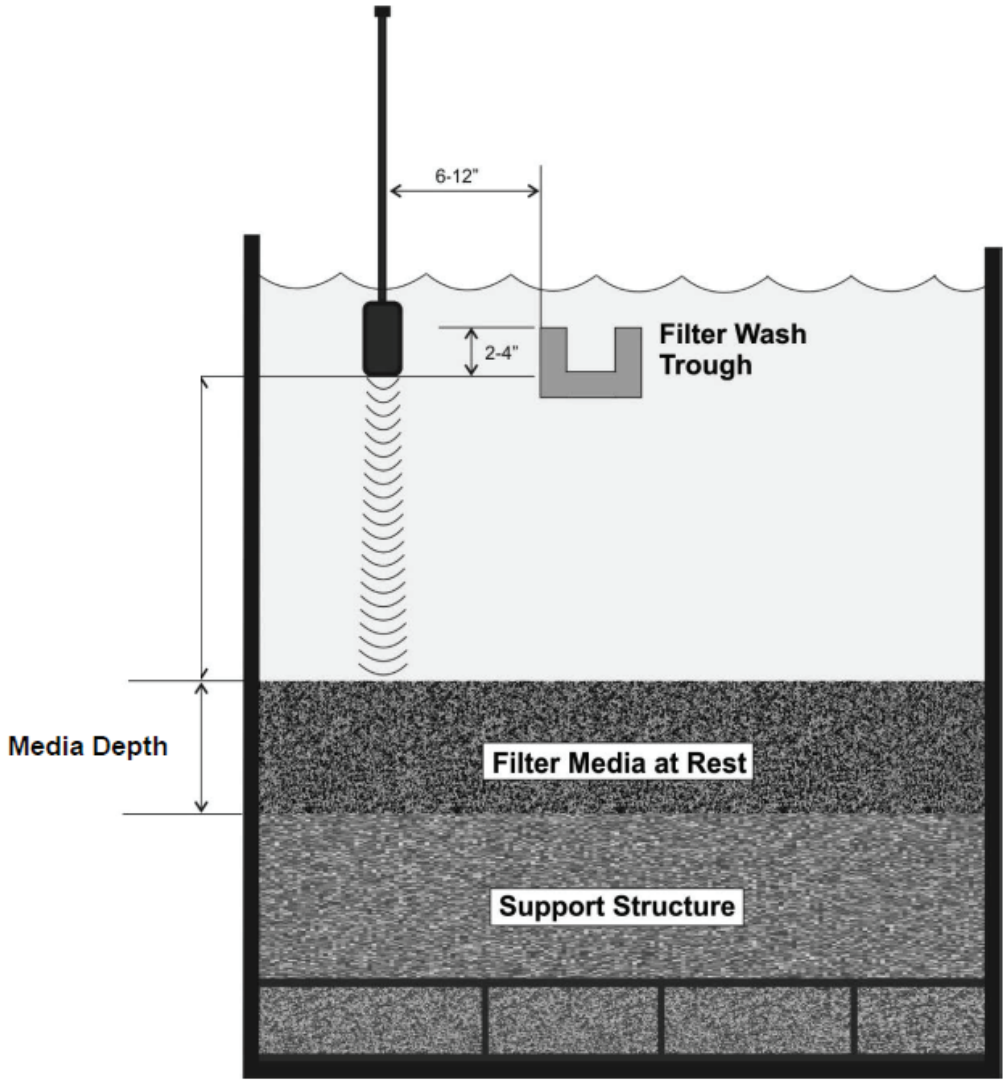


Figure 24: Filter configuration

Waveform Analysis

The FilterSmart Sensor produces a signal waveform (*Figure 25*) that is used to produce the media level measurement. The waveform is available as a diagnostic tool in the *Echo Profile* screen. See *Figure 25*.

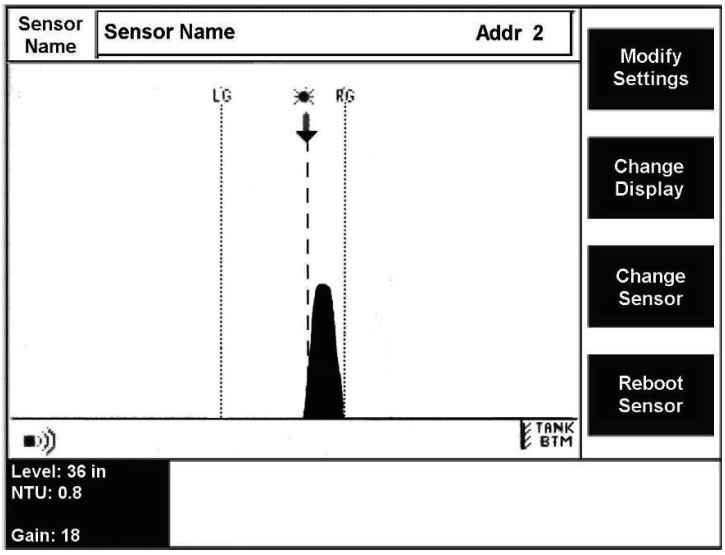


Figure 25: Echo profile screen

The signal waveform is presented graphically with the horizontal x-axis representing the filter depth and the vertical y-axis as the strength of signal at positions along the dimensional axis. The sensor is identified by symbol in the lower left corner of the graph, and the bottom of the expandable media is indicated in the lower right corner.

An interface is generally identified as a rising slope (left side) of the curve of a signal. This reflects a significant increase in the amplitude of signal at a particular location (distance from the sensor). Stable and repeated signals are given preference over more transient ones.

The selected signal is identified on the waveform by a dashed vertical line that is called a Candidate.

Signal Waveform Symbols

↓ The *Down Arrow* points to the current track. This position corresponds with the *Current Measurement*.

→ The *Right Arrow* indicates that a signal meeting the tracking criteria is located outside the gate, to the right. The measurement is only affected by this signal if the signal persists for repeated updates.

← The *Left Arrow* indicates that a signal meeting the tracking criteria is located outside the gate, to the left. The measurement is only affected by this signal if the signal persists for repeated updates.

!! The *Double Exclamation Mark* indicates that the current signal is insufficient for tracking purposes. The current measurement is held until sufficient signal returns. An "Echo Loss" message accompanies the output measurement on the controller if it persists longer than the *Echo Delay* setting. *Loss of Echo* is reported on the 4…20 mA circuit if the *Loss of Echo* parameter is activated (see *"Echo Loss (OFF)"*, *"Echo Delay (60)"* and *"Echo Loss Action (Cycle)" on page 40*).

COMMUNICATIONS, OUTPUTS AND NETWORKING

You may implement FilterSmart as a stand-alone instrument, or configure it in a wired or wireless RF field network arrangement. In a stand-alone environment, communication refers to analog signal outputs and digital communication with external devices. (See *"Stand-Alone Instrument Option" on page 9*.)

When implemented in a field network arrangement, communication additionally refers to information exchange and control functions between FilterSmart devices, as well as communication and output signals that are connected to the customer data and control systems. (See *"Field Network Option" on page 9*.)

Configuration of Individual Units and Networks

Multiple configurations are possible for the FilterSmart equipment.

Stand-Alone Instrument

A stand-alone instrument is a FilterSmart Controller with a Smart Sensor connected to the controller (see *Figure 26*).

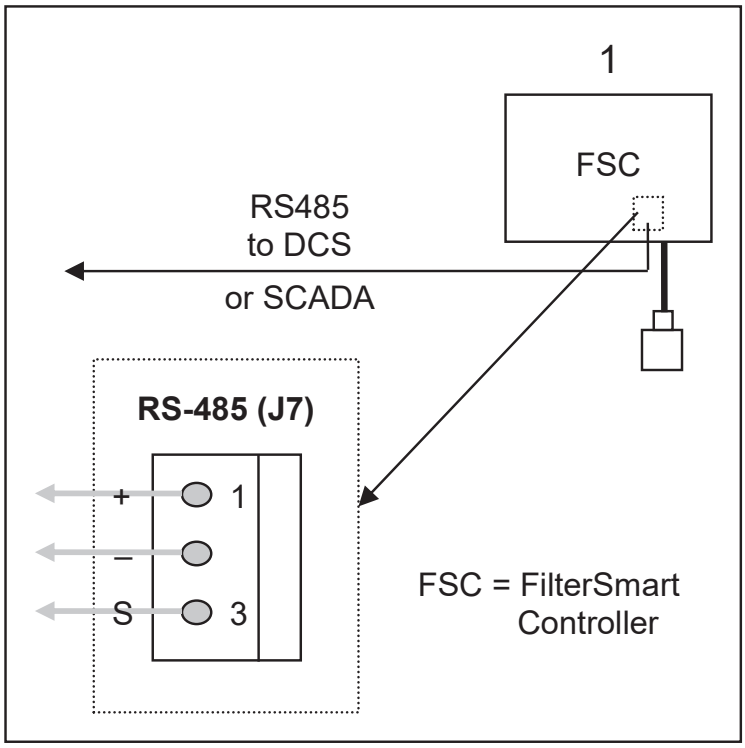


Figure 26: Controller with single sensor

Wired RS-485 Field Network

You can operate up to sixteen Smart Sensors with one FilterSmart Controller via two-wire RS-485 from a controller to each power supply unit. No user programming or other integration is required.

To create the wired network, use a shielded two-wire twisted pair (recommended Belden 9463) between each FSP and to the FSC. Make connections for the RS-485 communication line at the 3-pin terminal strip (J8) on each FSP and at the 8-pin sensor connector (J9) on the FSC as shown in *Figure 27 on page 34*.

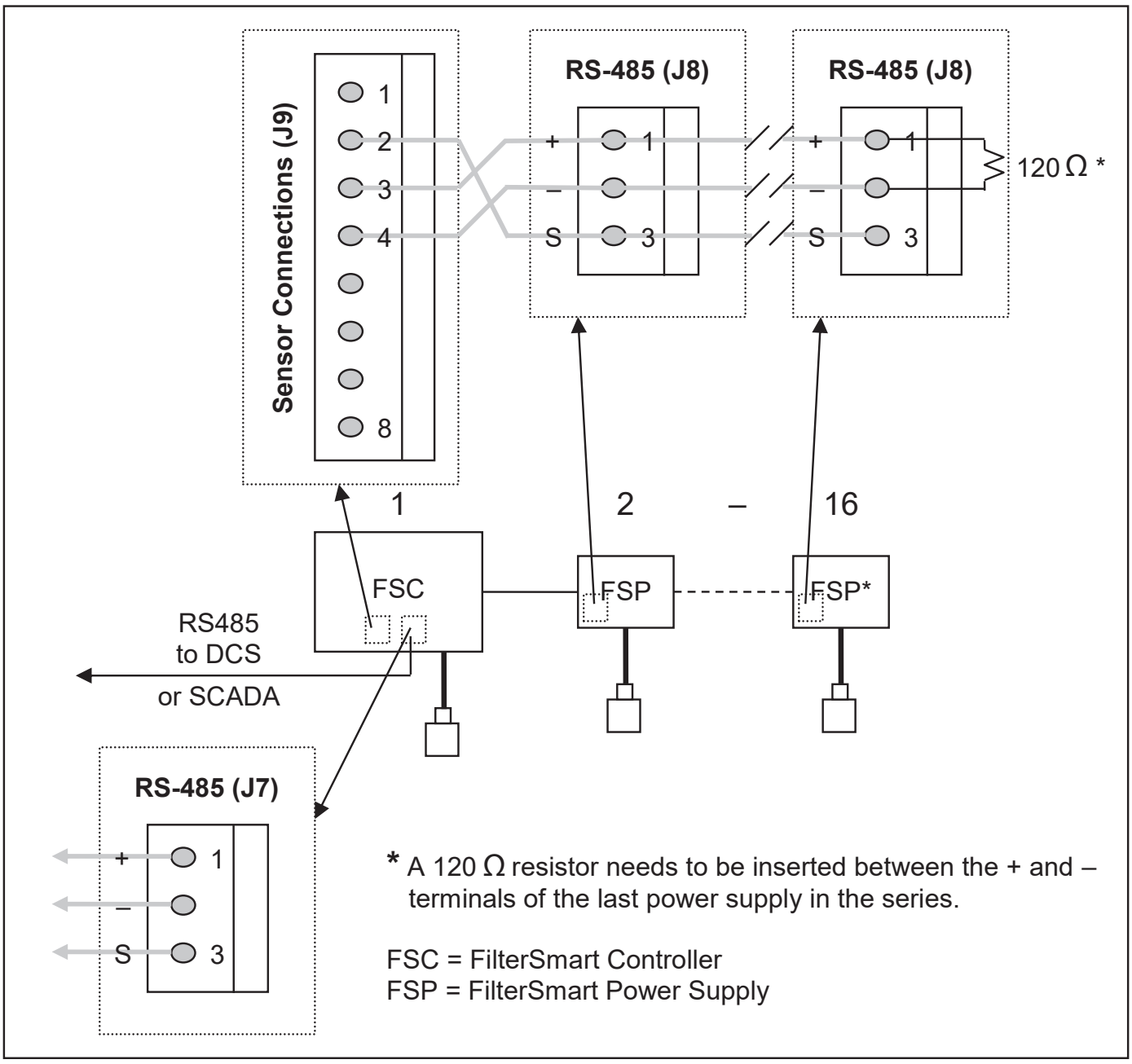


Figure 27: Single wired field network

Wireless (RF) Field Network

You can implement field networks as described and configured in *"Wired RS-485 Field Network" on page 33* using optional fully integrated RF modules without installing field interconnection cabling and conduit. Equip the controller and each power supply unit in the field network with an RF module. No user programming or other integration is required.

Figure 28 illustrates a single wireless RF field network configuration. You can integrate multiple RF Field Networks into a SCADA system by connecting controllers as shown in the "Customer Integration" section of *Figure 29 on page 36*.

IMPORTANT

Delays in data retrieval from multiple sensors can exist because of the unpredictable nature of wireless communication due to interference, distance, obstructions and so on. The wireless field network is therefore not recommended unless the local analog outputs are being used.

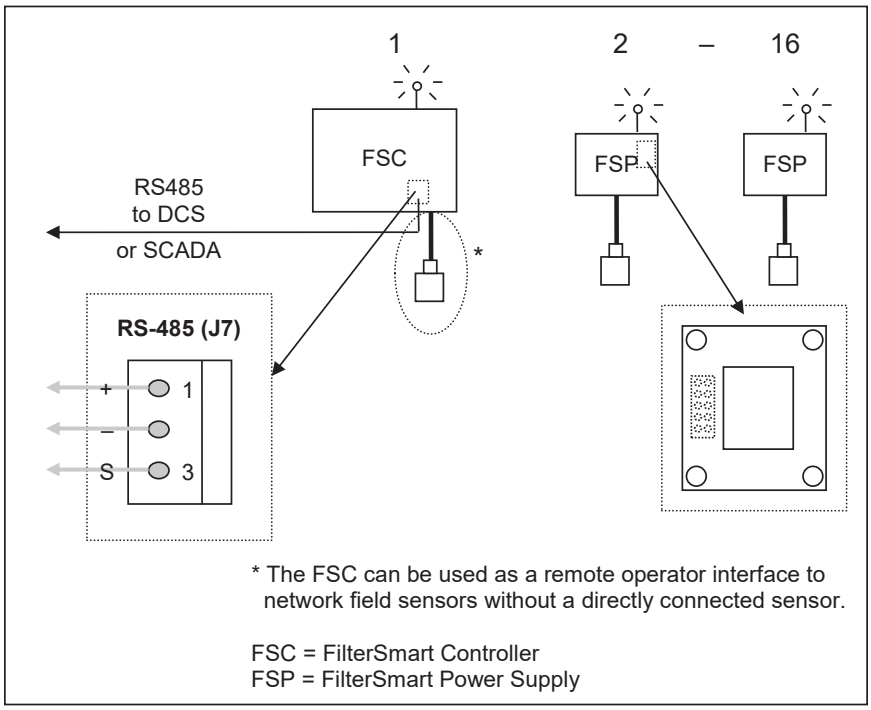


Figure 28: Single RF field network

Integrated Field Networks

You can interconnect FilterSmart controllers operating field networks in an integrated two-wire RS-485 network of up to 240 Smart Sensors. Each controller can maintain a network of up to sixteen sensors using either wired connections or the wireless radio modules. Connect the controllers using a two-wire twisted pair so that only one cable run has to be made to the control system. Customer Modbus RTU integration is required.

IMPORTANT

Do not connect the two-wire cable to the control system to the FSC until all sensors are installed and communicating with the local FSC.

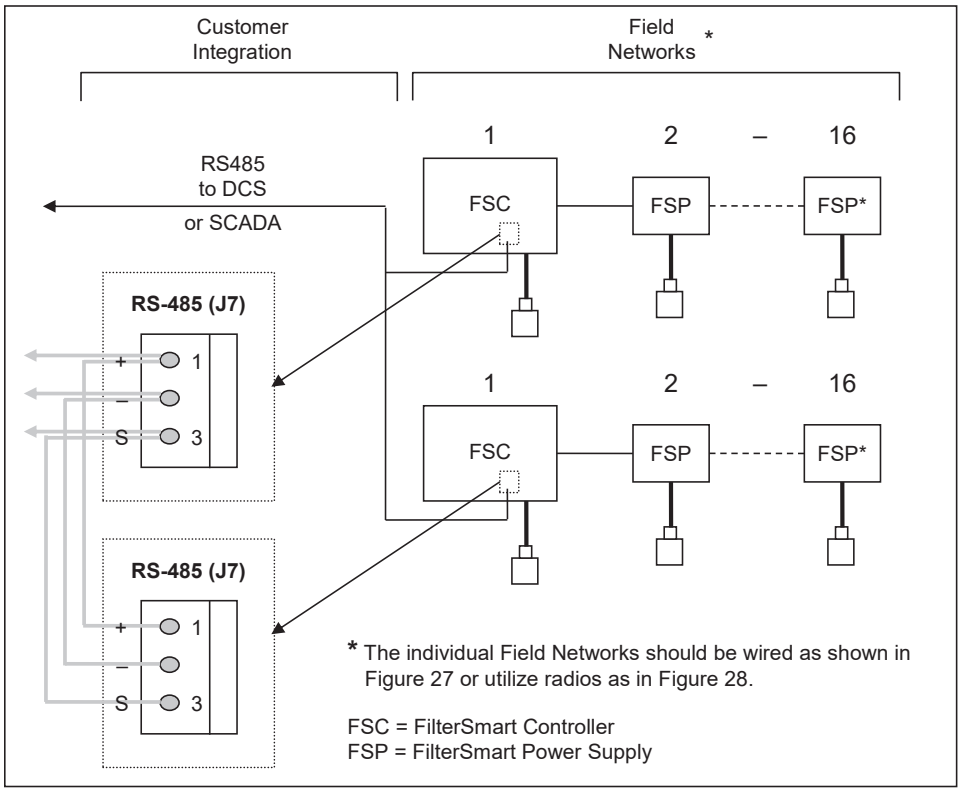


Figure 29: Integrated wired field network

Outputs and Communication Options

In addition to the measurement displayed on the installed FSC, you can access current measurements from each sensor through a Modbus RTU command request or an analog 4…20 mA current loop.

Factory remote service is additionally available (see *"Factory Remote Service" on page 38*).

RS-485 Modbus RTU

FilterSmart sensors respond to Modbus RTU command requests via the local FSC that is monitoring the sensor(s).

Connection

Use a shielded two-wire twisted pair (recommended Belden 9463) between the RS-485 3-pin connector (J7) of the FSC and the local control system.

IMPORTANT

Do not connect this two-wire cable to the FSC until all sensors are installed and communicating with the local FSC.

When communication is occurring through the RS-485 connection, an "RS-485" message appears in the lower left portion of most display screens.

Polling Basics

The supported baud rate is 9600 and the RTU format is 8 bits, no parity, 1 start, and 1 stop bit.

The slave address used for polling is each sensor's unique address that you entered when the FilterSmart equipment was commissioned. When multiple sensors are communicating with the FSC, poll each sensor's address separately for the desired Modbus value(s).

Recommended Polling

To obtain the current measurements, use Function Code 03 and poll for the following registers as desired:

- Register 40001 for Media Level
- Register 40002 for Turbidity
- Register 40003 for Expansion
- Register 40004 for Expansion Percentage

The returned values for *Media Level* and *Expansion* are in the sensor's selected *Units* and are reported as the base measurement multiplied by ten (for example, 42 = 4.2 units). The returned value for *Turbidity* is the current NTU value multiplied by 100 (for example, 135 = 1.35 NTU). The returned value for *Expansion Percentage* is the percentage value multiplied by 10 (for example, 154 = 15.4%).

For the most up-to-date information, retrieve only the desired data from each sensor.

Additional Information

The information provided in this manual only serves as a brief overview of the capabilities and data available via Modbus. See the "Modbus for FilterSmart" user manual for further detailed information on available commands, settings, and programming.

Primary Analog Current Loop

The sensor generates the 4…20 mA proportional current loop signal. Access the signal at pins 1 and 2 of the 4-pin 4…20 loop connector on the FSC (J10) or FSP (J6) that is supplying power to the sensor. The primary current loop is user-assigned for *Media Level*, *Expansion* (engineering units) or *Expansion %*.

Scale the *Primary Current Loop 4 mA Set Point* and *20 mA Set Point* (see *"4 mA Set Point (0.0)" on page 39* and *"20 mA Set Point (60.0)" on page 39*) to represent the installation environment with consistent scaling at the control device.

Turbidity Analog Current Loop

The turbidity 4…20 mA current loop output is factory scaled from 0.0…50 NTU and is not user-adjustable. Access the signal at pins 3 and 4 of the 4-pin 4…20 loop connector on the FSC (J10) or FSP (J6) that is supplying power to the sensor.

The *Turbidity* current loop is not assignable to a different function.

Factory Remote Service

FilterSmart Controllers are designed for optional installation of a cellular service modem. With the user's authorization, this facility enables startup and service by expert factory technicians. Cellular connectivity is included with the service and is limited to areas where cell service is available.

This service uses the onboard RS-232 serial connection. When communication occurs through this port, a notification message appears on most display screens.

See *Figure 30* for instructions on how to properly install and remove the modem from an FSC.

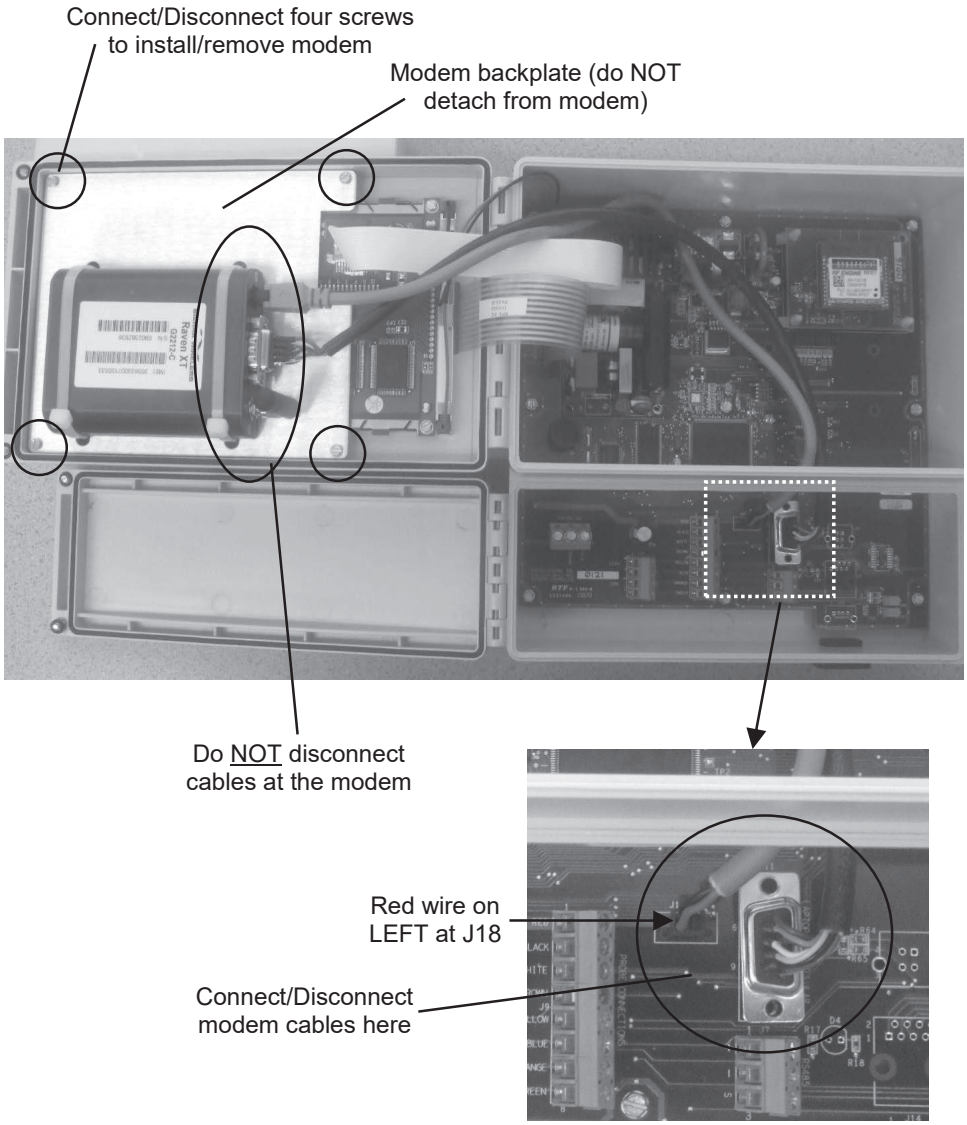


Figure 30: Proper installation and removal of modem

INSTRUMENT PROGRAMMING PARAMETERS

Controller and Smart Sensor parameter settings are established at the *Modify Settings* and *Advanced Settings* screens. Standard default parameters exist in all instruments until they are modified. Most parameters should be left at the default value unless instructed by a factory technician.

Default values for each parameter discussed below are indicated by parenthesis ( ).

Modify Settings Parameters

Parameters found at this screen are the primary instrument settings and may require adjustment to meet the requirements of the installation and process environment.

Units (in.)

The *Units* parameter establishes the desired engineering units that the instrument uses for all calculations and displayed values.

Options for *Units* are: Inches (in), and Centimeters (cm).

Media Depth (36)

Media Depth is the amount of expandable media in the filter. You must enter an accurate value during setup for the correct *Media Level* to be reported and for accurate expansion percentage calculations.

The range for *Media Depth* is 0…240 inches.

Wiper Timing (240)

Wiper Timing establishes the time (minutes) between wiper cycles. The sensor wiper also operates automatically on detection of signal loss regardless of the selected *Wiper Timing* setting. This reduces the need to establish a short wiper timing sequence and prolongs the life of the wiper mechanism.

The range for *Wiper Timing* is 0 [OFF] to 240 minutes.

Primary 4…20 mA (Media Level)

The *Primary 4…20 mA* setting determines what measurement is output on the primary 4…20 mA connection. *Turbidity* is always output on the secondary connection.

Options for *Primary 4…20 mA* are: *Media Level*, *Expansion* (selected engineering units), and *Expansion %* (percent of media bed depth).

4 mA Set Point (0.0)

The *4 mA Set Point* establishes the instrument measurement value at which you expect the sensor to output a current of 4 mA. Establish the same set point value in the control device that the instrument is connected to.

The range for *4 mA Set Point* is *0 to Total Measurement Range* or *0…50%* depending on the option selected in *"Primary 4…20 mA (Media Level)"*.

20 mA Set Point (60.0)

The *20 mA Set Point* establishes the instrument measurement value at which the user expects the sensor to output a current of 20 mA. Establish the same Set Point value in the control device that the instrument is connected to.

The range for *20 mA Set Point* is *0 to Total Measurement Range* or *0…50%* depending on the option selected in *"Primary 4…20 mA (Media Level)".*

Echo Loss (OFF)

Echo Loss provides an alarm function through the 4…20 mA current loop signal when the *Echo Loss* is set to ON. The selected *Echo Loss* Action is executed after loss of echo persists for the time lapse defined by the *Echo Delay* setting.

The options for *Echo Loss* are: *ON* and *OFF*.

Echo Delay (60)

Echo Delay establishes the amount of time (in minutes) that the sensor must experience a loss of echo before initiating the *Echo Loss Action*.

The range for *Echo Delay* is 0…255 minutes.

Echo Loss Action (Cycle)

Echo Loss Action determines the state that the current loop adopts in response to loss of echo when the *Echo Loss* alarm function is activated.

The options for *Echo Loss Action* are: *4 mA*, *20 mA* and *Cycle*. With *Cycle* selected, the output continually alternates between 4 mA and 20 mA until the loss of echo condition ceases.

Display Contrast (55)

Display Contrast allows you to adjust the *LCD Contrast* for optimal visibility. The range for *Display Contrast* is 0…255.

Advanced Settings Parameters

Additional parameters are found at this screen. To access this screen, press the **Advanced Settings** soft key at the *Controller Setup* screen.

Auto Gain (ON)

When activated, *Auto Gain* continually monitors signal characteristics and adjusts signal amplification in response to changes in the process environment. Keep *Auto Gain* **ON** unless otherwise advised by a factory-trained technician.

The options for *Auto Gain* are: *ON* and *OFF*.

Current Gain (30)

With *Auto Gain* ON, *Current Gain* is established automatically and is not accessible as a parameter that can be modified manually. With Auto Gain OFF, this parameter establishes the constant level of signal amplification at which the instrument will operate.

The range for *Current Gain* is: 0…100.

Total Measurement Range (Auto Calculated)

Total Measurement Range is the distance from the face of the sensor to the bottom of the expandable media. This value is automatically set during the sensor initialization process based on your entry of *Media Level*. Changes to this parameter value after initialization will impact the indicated *Media Level*. Increase the value to increase *Media Level*; decrease to decrease *Media Level*.

The range for *Total Measurement Range* is: 36…384 inches.

Sensor Blanking Zone (12.0 inch)

Sensor Blanking Zone is the area near the sensor that will not produce measurements. The *Sensor Blanking Zone* must be at least 12 inches.

Sensor Measurement Limit (Auto Calculated)

Sensor Measurement Limit sets the total measurement span. It is automatically set to 4 inches greater than the location of the media (*Total Measurement Range* minus *Media Depth*) on initialization and should generally be maintained at 4…6 inches deeper than the media location.

The range for *Sensor Measurement Limit* is: 12…384 inches.

Level Simulation Test

Selecting the *Level Simulation Test* option provides access to the Simulation Test Setup page. The simulation test provides an opportunity to verify proper operation of the level analog output loop. Configure the analog loop settings (*Primary 4…20 mA* parameter and *20 mA Set Point* parameter) prior to simulation for a test reflective of the desired configuration. The test value carries the sensor's specified units. The allowable test range is from a zero value (output of 4mA) to the sensor's *20 mA Set Point* value (output of 20 mA).

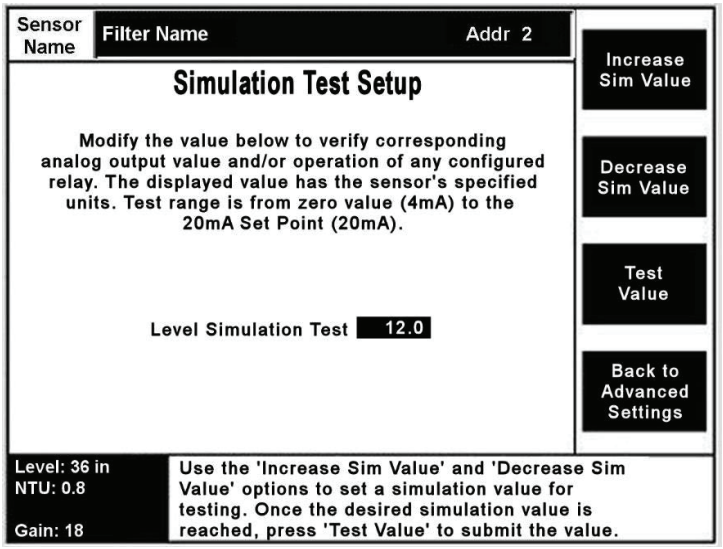


Figure 31: Level simulation test setup screen

Use the *Increase Sim Value* and *Decrease Sim Value* options to modify the simulation value. Once the desired output is reached, press the **Test Value** option to send the value to the sensor and output the scaled analog value on the level current loop.

For units purchased with integrated relays, the level simulation value also impacts the status of any relays configured for media level, media expansion or expansion percentage. Activate and configure the relays prior to performing the simulation test (see *"Relays" on page 48*).

NOTE: This functionality is available on controller firmware version 1.06 and later in conjunction with Sensor firmware version 38 and later.

Aux Simulation Test

Select the **Aux Simulation Test** option to access the *Simulation Test Setup* page. The simulation test provides an opportunity to verify proper operation of the auxiliary analog output loop. Turbidity is always output on the auxiliary analog loop for FilterSmart sensors. The test range is 0…50 NTU.

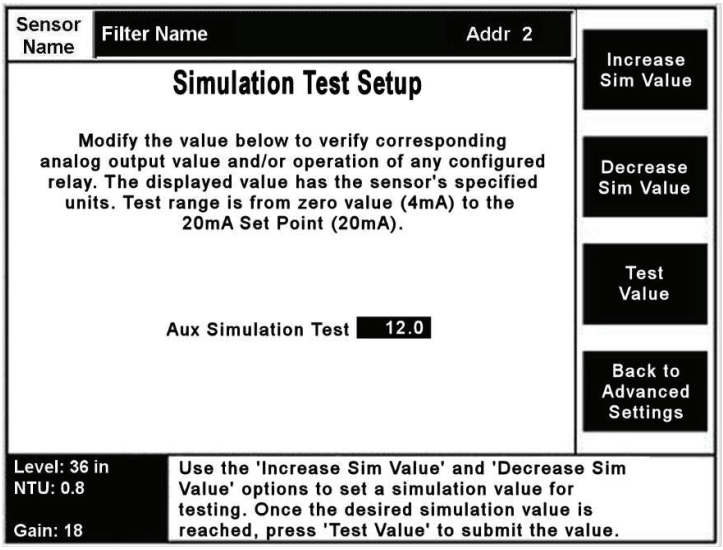


Figure 32: Aux simulation test setup screen

Use the *Increase Sim Value* and *Decrease Sim Value* options to modify the simulation value. When the desired output is reached, press the **Test Value** soft key to send the value to the sensor and output the scaled analog value on the Aux current loop.

For units purchased with integrated relays, the simulation value also impacts the status of any relays configured for turbidity. Activate and configure the relays prior to performing the simulation test (see *"Relays" on page 48*).

NOTE: This functionality is available on controller firmware version 1.06 and later in conjunction with sensor firmware version 38 and later.

Set Sensor to Default Settings

Since the FilterSmart sensor auto-configures to its environment during initialization, you can set the sensor back to default values if the sensor is moved or relocated. All parameters including *Media Depth*, *Sensor Name*, and the auto-set dimensional parameters are reset to default values. The sensor address is maintained. See *"Returning Sensor to Default Settings" on page 24*.

MAINTENANCE AND TROUBLESHOOTING

Preventive Maintenance

Sensor Cleaning and Maintenance

All Sensors with Self-Cleaning Wipers

The Wiper mechanism and blade are designed to remove air/gas bubbles and light materials that may collect on the face of the sensor and degrade signal quality. Supplemental manual cleaning may be required in processes in which suspended solids attach aggressively to the face of the sensor.

Wiper blade and motor life varies with process conditions and the user-established frequency of operation (see *"Wiper Timing (240)" on page 39* parameter). It is generally expected that the wiper blade assembly requires replacement yearly and the wiper motor requires replacement every two years in typical municipal water and wastewater treatment filter applications.

Inspect the sensor frequently during the initial 3 to 6 months of operation to determine whether supplemental cleaning is needed and that the wiper blade assembly is intact. From these observations, establish an ongoing preventive maintenance schedule.

⚠CAUTION

UNLESS DETERMINED TO BE INSUFFICIENT FOR THE PROCESS ENVIRONMENT, SET WIPER TIMING (ADVANCED SETTINGS) TO 240 TO REDUCE WIPER BLADE AND MOTOR WEAR. LOWERING THIS PARAMETER REDUCES MOTOR ASSEMBLY LIFE PROPORTIONATELY.

Wiper Assembly Replacement

The FilterSmart Sensor Wiper Blade Assembly (Part No. 03-0497) is field-replaceable.

1. Remove the wiper by unscrewing in counter-clockwise direction.
2. Secure and retain the stainless steel spacing washer from the wiper shaft for use with the replacement wiper.
3. Screw the new wiper clockwise until the arm makes contact with the seated spacing washer, plus 1/8th of a turn. DO NOT OVER TIGHTEN. Over-tightening may result in the wiper not operating. In this case, a "Wiper Stall" message displays at the FilterSmart Controller.

Sensor Cleaning and Inspection

1. Remove the sensor from the process using safety procedures, protective clothing and equipment appropriate for the process environment. Use protective gloves and eyewear when there is the possibility of exposure to dangerous or unsanitary materials or conditions.
2. Carefully remove debris, rags and similar material that may have attached to the sensor. Do not rotate the wiper blade by hand.
3. Use a soft to medium bristle non-metallic brush or soft cloth and mild detergent to wipe away algae, slime and accumulations of suspended solids in the process liquid. For disinfection, use 8 ounces of regular bleach (sodium hypochlorite 8.25% solution) to one gallon of water.
4. Before returning the sensor for service, operate the wiper system to make sure that it rotates in the expected manner and that the wiper blade is secure. In normal operation, the wiper blade with make 1…3 rotations when power is supplied or when the wiper timing setting is changed.

Other Routine Maintenance

- Visually inspect the instrument's electronic components monthly during normal filter "walk downs" to determine that there are no obvious signs of damage to the equipment and that mounting brackets and hardware are secure. Tighten mounting bolts as required.
- Observe the sensor to make sure it is fully submerged below the top of the filter wash trough and that there are no rags or similar debris wrapped around it.

Troubleshooting

The following recommendations address the most often encountered troubleshooting needs with the FilterSmart equipment. If the described procedure does not resolve the problem, contact Badger Meter for further assistance.

Comm Error Message

A "Comm Error" message indicates that communication between the controller and Sensor(s) has been interrupted for an extended period of time. Verify that the sensor associated with the alarm is properly powered and that all sensor and communication cables are connected correctly.

In the case of a Wireless Field Network of Sensors, consider metal structures, cabinets and mounting fixtures that may intervene in the path of the RF signal.

Echo Loss Message

An "Echo Loss" message indicates that the instrument does not have a signal that is reliable for measurement within the current parameter range. This can occur as a result of the sensor not being submerged in water or as a result of excessive air releasing from the filter and collecting on the face of the sensor. Temporary loss of signal during filter draw-down, surface-wash or air-scouring conducted as preparatory steps to the backwash may cause loss of signal. Loss of signal at these times is expected and does not interfere with measurement performance.

Corrective action includes a physical inspection of the sensor(s) and process to determine whether any of the above referenced conditions exist. Confirm that the wiper arm is in place and that the wiper turns when (1) power is cycled, (2) the sensor *Reboot* command is called, or (3) the *Wiper Timing* setting is changed.

Loss of signal can also be the result of incorrect operating parameters in the sensor. Since the FilterSmart sensor auto-configures the dimensional parameters during initialization, if the sensor was recently relocated or moved, the sensor may need to be allowed to adjust to the new location. This can be achieved by initiating *"Set Sensor to Default Settings" on page 42* or by extending the *"Sensor Measurement Limit (Auto Calculated)" on page 40* and then rebooting the sensor.

Contact Badger Meter for assistance if the problem is not resolved.

Validating Message

"Validating" is the "handshake" process that occurs when an FilterSmart Controller initiates communication with the sensor(s). This happens when the controller is initialized or when a sensor is manually added to the sensor database. This step is normally completed rapidly and may not be noticed by the user. If the "Validating" message continues for an extended period of time, there is a communication problem that may require corrective action (see *"Validation Failure Message" on page 44*).

Validation Failure Message

If a sensor does not validate as expected, the controller has been unable to communicate with the sensor and the "Validation Failure" message displays. Check all sensor and network cabling and connections and re-check main power to the controller and all power supply units. If a wireless sensor network is in use, investigate possible impediments to network communications.

Wiper Stalled Message

A "Wiper Stalled" message appears if the wiper does not operate when expected or if rotation of the wiper blade is not detected. It may also indicate drag on the wiper motor as a result of debris being attached to the wiper blade or shaft. Visually inspect the sensor to determine that the wiper blade and shaft are free of debris. Verify that the wiper is securely connected to the wiper shaft and that it turns freely (1…3 revolutions) when power is cycled to the sensor or the *Wiper Timing* parameter is changed. Replace the wiper blade, as indicated in *"Preventive Maintenance" on page 43*.

Wiper Motor Failure Message

The "Wiper Motor Failure" message indicates an internal electronic failure of the wiper motor. Contact Badger Meter for repair or replacement options.

NOTE: Wiper motor failure may cause unreliable measurements.

Analog Output Discrepancy

FilterSmart 4…20 mA devices are active (powered) and isolated current loops. Check that no other power or isolation is present on the loop and confirm that no other electronic devices or electrical elements intervene on the current loop. Check that appropriate signal cable is in use.

Disconnect loop cables from the FilterSmart equipment and measure the current output to determine whether it corresponds with the measurement indication from the instrument.

Sensors Not Detected

If sensors are not detected or a "No Sensors Found" message displays, confirm that all sensor and communication cables are securely landed at the respective controller or power supply unit(s) and that main power is ON.

If a controller operates more than one sensor, confirm that all sensors have been added to the Network as directed in *"" on page 53* and that each has a unique address designation. If multiple sensors have the same address number, the controller is not able to establish communication with those sensors. If unique sensor addresses have not been assigned, power OFF the equipment and follow the steps in *"" on page 53*.

If a wired field network is being used, see *"Wired RS-485 Field Network" on page 33* and verify that all connections are made at the proper terminals.

Radio (RF) Communications

Sensor specific communications troubleshooting:
LEDs located near the serial port of each FSP give an indication of the communication that is occurring in the network. The Status LED should be on solid and the RS-485 LED should flash with each transmitted message.

If the Status LED is flashing, cycle power on the FSP.

If the Status LED is on solid and the RS-485 LED is not flashing, verify that the radio is seated properly and cycle power to determine if communication can be re-established.

Persistent "Acquiring Waveform" Message

If an "Acquiring Waveform" message appears for an extended period of time on the Echo Profile screen, a search of the network may be necessary to establish proper communication with the sensor. Go to *Modify Settings* > *Controller Setup*, select the *Auto Detect Sensors* option and press the **Auto Detect Sensors** soft key. After a few seconds, the display redirects to a display screen.

A persistent message appears if an external device, such as an integrated control system, is constantly requesting information from the sensor(s). Temporarily disconnect the external device to see if waveform data can be gathered from the sensor. If this resolves the issue, modifications to the external device's polling routine are likely needed.

SYSTEM OPTIONS

Integrated Wireless Radio (RF) Modules

Communication between the controller and associated power supply units can be achieved with integrated wireless radio modules to eliminate the need for cabling and conduit between units.

General Overview

The radios use a proprietary message structure for communication between units and use mesh networking capabilities to achieve redundancy and reliability.

Internal Configuration

In this configuration, the radio module is mounted inside the controller or power supply enclosure. An external antenna is then affixed to the outside of the enclosure with a U.FL to RP-SMA cable connecting the antenna to the module. The module additionally requires that a two-wire cable be connected between the radio's 4-pin terminal strip (J2) and the 8-pin terminal strip on the associated controller (J9) or power supply (J4). The cable should link red to red terminal locations and black to black (see *Figure 33*).

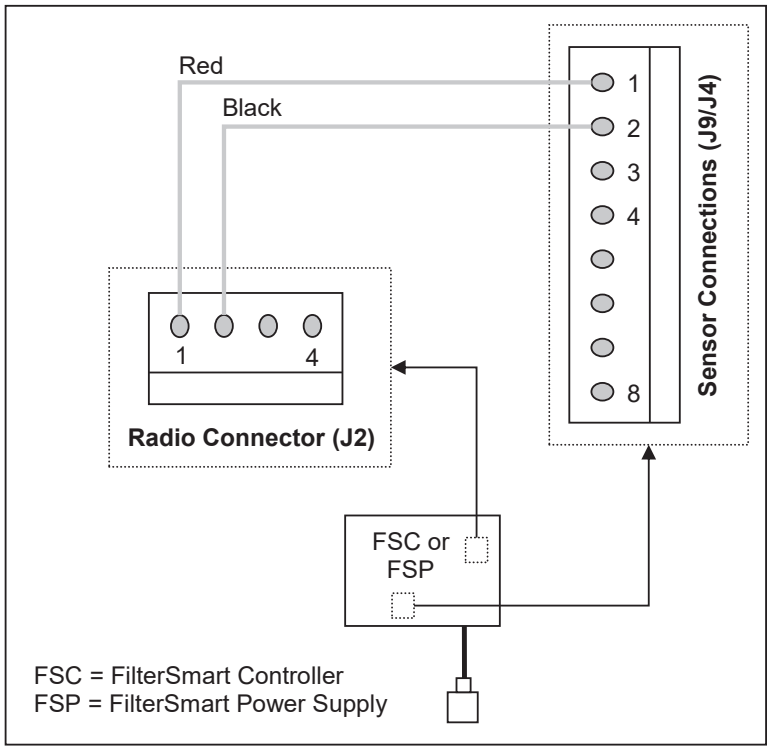


Figure 33: Connections for wireless radio module (internal)

External Configuration

In this configuration, the radio module is mounted in a separate enclosure that can be located in an optimal location. An external antenna is affixed to the outside of the enclosure with a U.FL to RP-SMA cable connecting the antenna to the module. A 4-wire cable is required to connect the radio's 4-pin terminal strip (J2) and the 8-pin terminal strip on the associated controller (J9) or power supply (J4). The cable should link red to red terminal locations, black to black, white to white, and brown to brown (see *Figure 34 on page 47*).

This configuration is ideal when controllers or other units are placed in buildings or other locations that may create less than ideal paths for radio transmissions. The radio can then be located in a more optimal location.

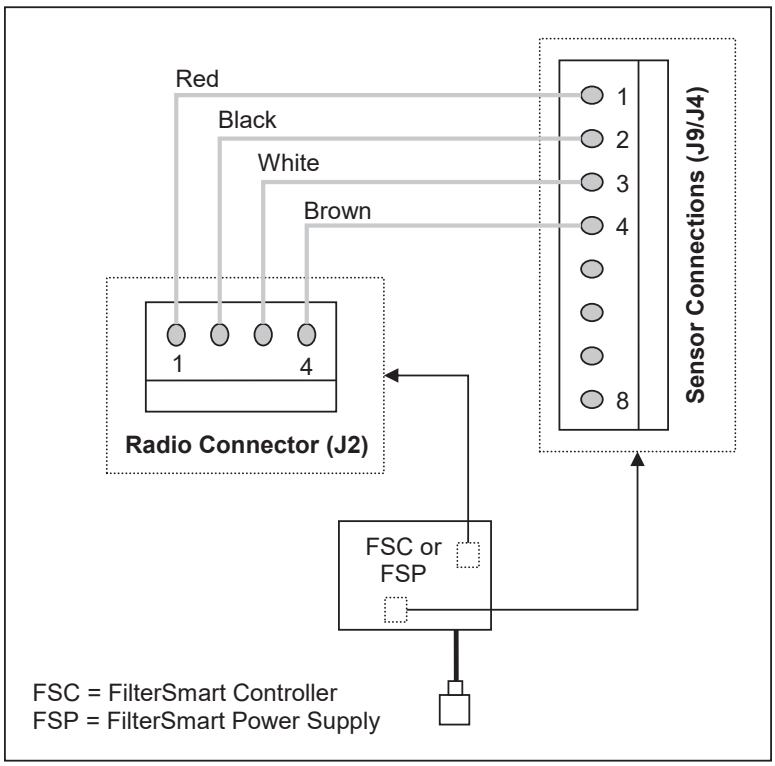


Figure 34: Connections for wireless radio module (external)

Equipment Orientation for Units with Integrated Wireless Radio Modules

Orient equipment containing the integrated wireless radio modules so that the antenna mounting location is on the side of the enclosure with the antenna pointed in the upward direction. See *Figure 35*.

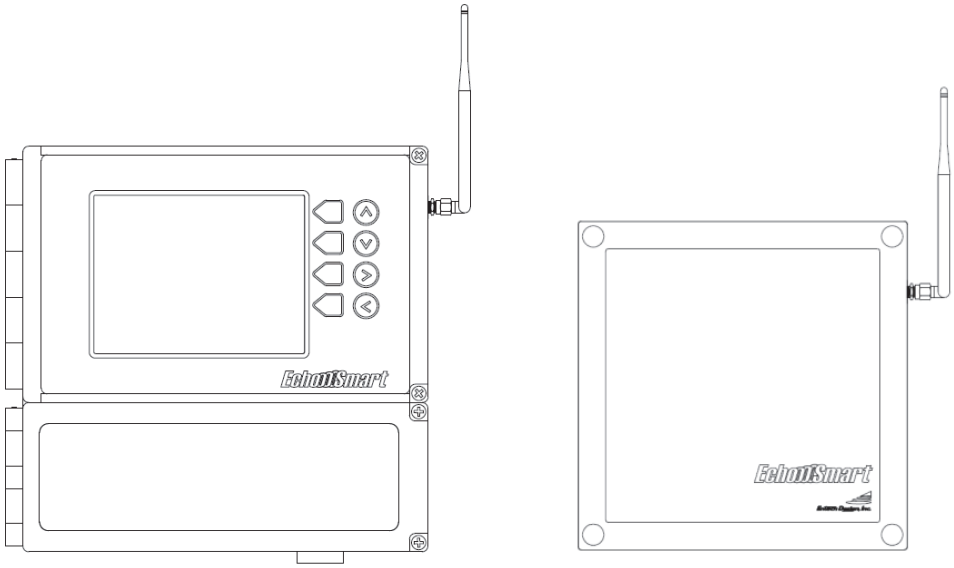


Figure 35: Orientation of units with wireless radio modules

Relays

Relays require an additional circuit board installation in the FilterSmart controller. Relays are not available in the FilterSmart power supply unit.

General Overview

Four SPDT relays may be added as an option to a controller. Each relay is capable of monitoring the media level, turbidity, media expansion, expansion percentage or can be configured as a fail-safe alarm. The relays can be assigned to separate sensors or multiple relays can be assigned to one sensor.

Operation

To access relay controls, press the **Set Up Relays** soft key from the *Controller Setup* screen (see *Figure 14 on page 22*).

The relay *Status* must be set to **ON** for the relays to operate. The sensor associated with each relay is listed below the *Status* setting. Each relay can be set to monitor the media level, turbidity, media expansion, expansion percentage, or can be set as a fail-safe alarm by cycling through the *Change Assignment* options.

When monitoring media level, media expansion, expansion percentage or turbidity, the *Enable* > option determines the value at which the relay is energized and changes states. The *Disable* < option determines the value at which the relay de-energizes and changes states.

When set as a fail-safe alarm, pins 2 and 3 of the relay are energized under normal operating conditions. Pins 2 and 3 are de-energized when the FilterSmart Controller is powered off or a fault due to loss of echo or a communication error is detected on the associated sensor.

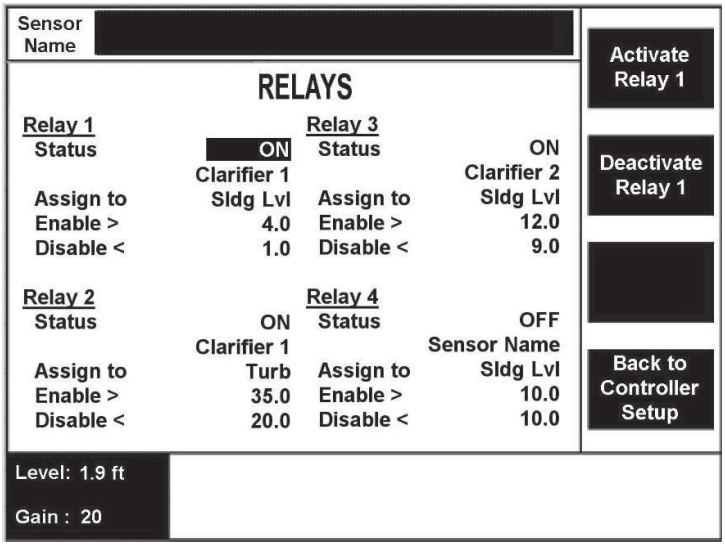


Figure 36: Relays screen

Cabling and Connections for Relays

This section describes the physical layout and terminal connections for the relays.

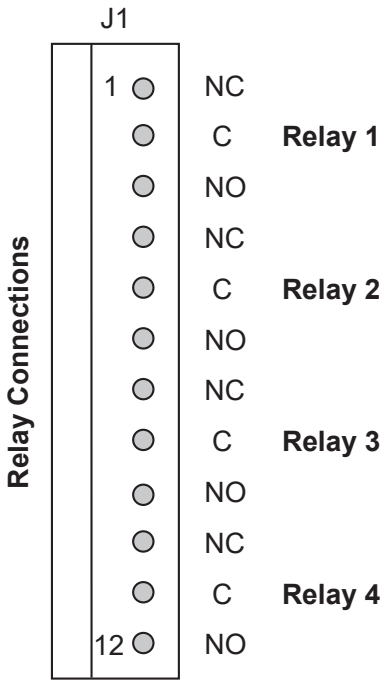


Figure 37: Connections for relay board

Relay Connections (J1)		
Pin #	**Relay**	**Description**
1	1	Normally Closed
2		Common
3		Normally Open
4	2	Normally Closed
5		Common
6		Normally Open
7	3	Normally Closed
8		Common
9		Normally Open
10	4	Normally Closed
11		Common
12		Normally Open

Figure 38: Table of relay connections

Digital (RS-485) to Analog (4…20 mA) Converter

The FilterSmart Controller can be paired with the Badger Meter Analog Output Module to obtain analog measurements from all networked sensors in one location. Compatible with FilterSmart Controller Firmware Version 1.05 and later.

Converter Overview

The Digital-to-Analog Converter can be configured with up to sixteen (16) outputs. The converter uses the RS-485 Modbus data from the controller and generates the corresponding analog output. Each channel can be customized with the sensor address and output value (media level, media expansion, expansion percentage or turbidity).

Converter Specifications

Input Power	18…30V AC
Mounting	DIN rail mount
Outputs	Up to 16 isolated analog outputs

Converter Cabling and Connections

A shielded two-wire twisted pair should be used between the controller's RS-485 connector (J7) and the converter's serial RS-485 terminal location.

See *Figure 39* for information related to powering and connecting all cables to the converter.

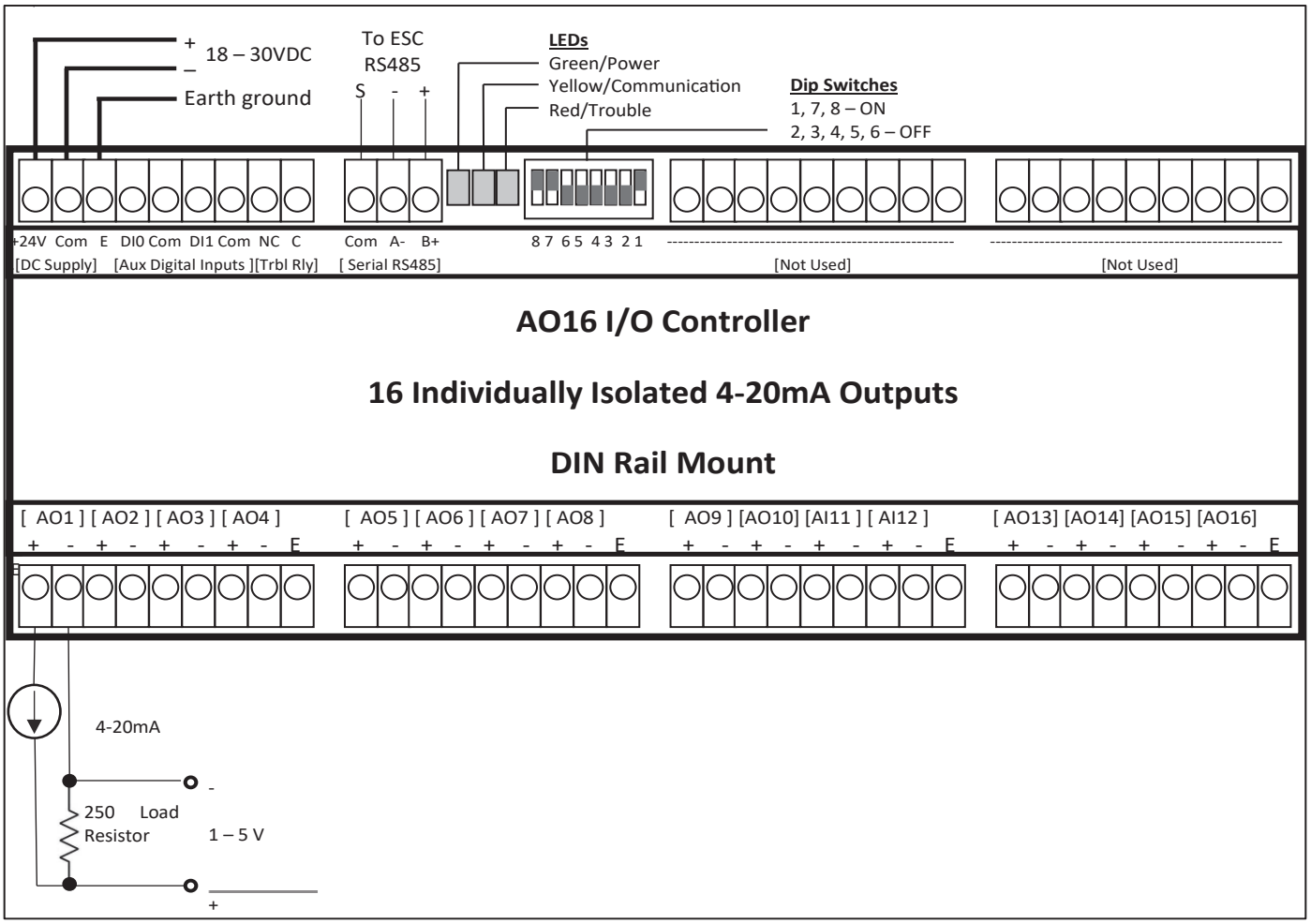


Figure 39: Analog output module connections

Configuring the Converter

To access the setup menu, from the *Controller Setup* screen, highlight the *Digital to Analog Output Setup* option and press the **D to A Output Setup** soft key. A screen similar to *Figure 40* appears.

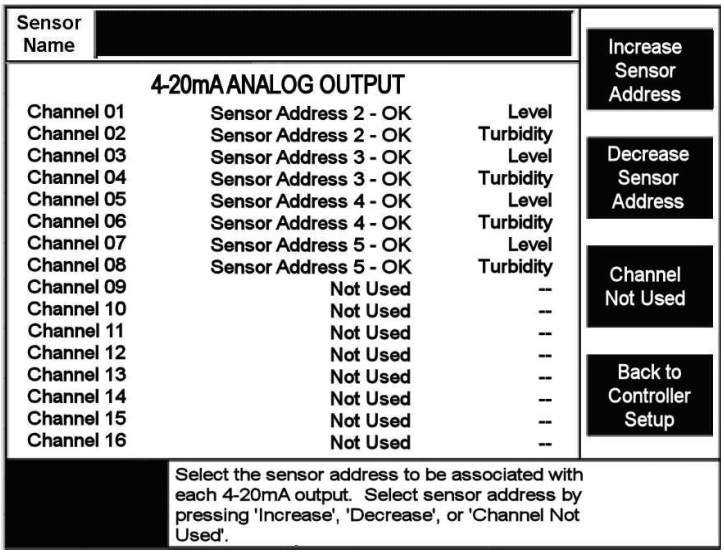


Figure 40: Digital to analog converter setup screen

Use the *Increase Sensor Address* and *Decrease Sensor Address* options to select which sensor's data is output on each channel. When scrolling through the addresses, an "OK" message is reported next to the address when that sensor is in the controller's database. Two question marks (??) are appended to the address when that address is not present in the controller's database of sensors, indicating that no value is available for the analog output. In this case, establish communication with the sensor or select another address.

Navigate to the right column to select the measurement to be output on each channel. The options are:

- *Primary 4-20 Value*; this value is set from the *Settings* page with options of *Media Level*, *Expansion*, and *Expansion %*; see *"Primary 4…20 mA (Media Level)" on page 39*
- *Turbidity*

While any sensor's output can be assigned to any channel, each unique output can only be assigned to one channel (for example, the *Turbidity* output for Sensor Address 2 can only be configured on one of the channels). Only one channel is updated with each unique output.

NOTE: If a sensor's address is changed after configuration of the Analog-to-Digital Converter has been performed, update the configuration to reflect the address change. Sensor address changes cannot be automatically updated on this configuration screen.

Analog Outputs

Each independent analog output is factory-calibrated and is optically isolated from the DC supply and from each other.

The sensor's *4 mA Set Point* and *20 mA Set Point* (see *"4 mA Set Point (0.0)"* and *"20 mA Set Point (60.0)" on page 39*) should be scaled to represent the installation environment with consistent scaling at the control device. The *Turbidity* value is factory scaled from 0…50 NTU and is not user-adjustable.

Figure 41 describes the analog output value that is reported under various sensor operating conditions.

Condition	Output
Normal	Current Scaled Value
Sensor Initializing	Cycle
Loss of Communication with Sensor	2 mA
Echo Loss	4 mA, 20 mA, or Cycle (see Echo Loss Action setting)
Channel Not Configured	0 mA

Figure 41: Analog output behavior table

QUICK START GUIDE

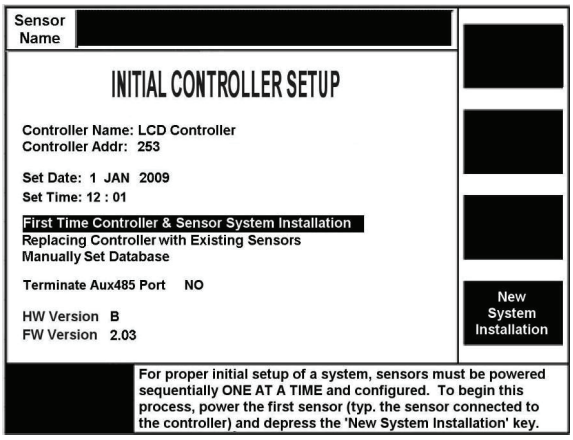
Configuring a Single Sensor

1. See *"Installation of Equipment" on page 27* and *Figure 21 on page 28* BEFORE INSTALLING SENSORS.
2. Make sure all sensor connections are correct and that power is properly applied to the device.

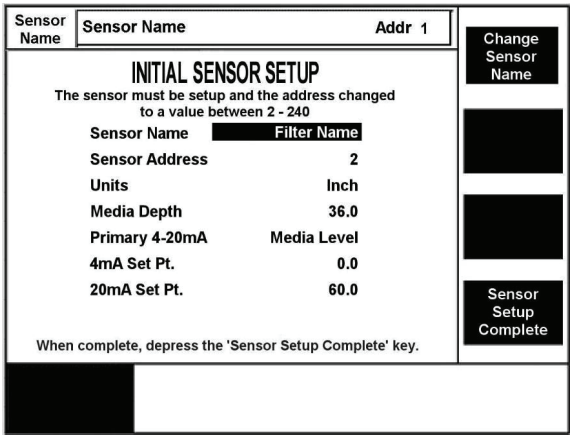
IMPORTANT

Disconnect any outside RS-485 device from the FSC prior to initiating Controller Setup to avoid communication errors.

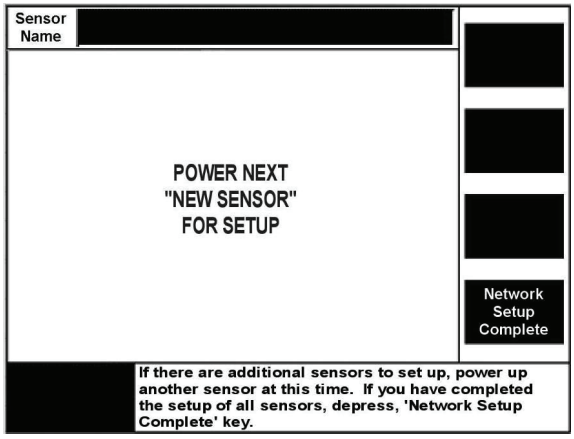
3. From the *Initial Controller Setup* screen, press the **New System Installation** soft key. This routine takes approximately 20 seconds to complete.



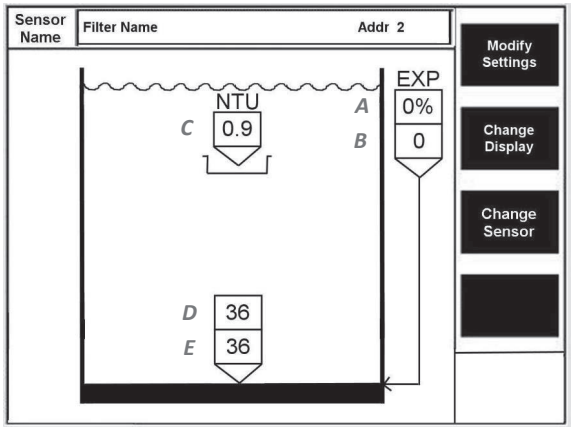
4. Change the *Sensor Address* to a unique value other than 1 and change the *Media Depth* setting to the amount of expandable media in the filter. If using analog outputs, also set the *4…20 mA Set Points* and the desired output for the *Primary 4…20 mA* current loop.



5. When the message "Power Next New Sensor for Setup" displays, press the **Network Setup Complete** soft key.



6. You will be directed to the *Filter View* screen. The sensor goes through an auto-setup initialization process and then begins to report the current measurements.



7. If using an external RS-485 polling device, connect it now. See *"RS-485 Modbus RTU" on page 36* for recommendations and information regarding an RS-485 connection.

Configuring a Sensor Network

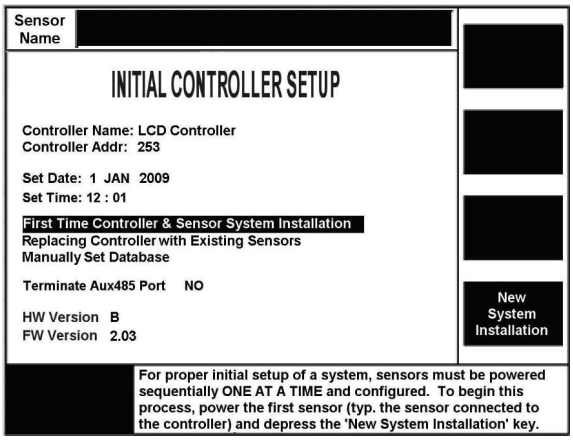
Follow these instructions for a FilterSmart Controller to communicate with more than one sensor in a network arrangement.

1. See *"Installation of Equipment" on page 27* and *Figure 21 on page 28* BEFORE INSTALLING SENSORS.
2. Make sure all sensor connections are correct and that power is properly applied to the FilterSmart Controller. If a sensor is not directly connected to the controller, power the first FilterSmart Power Supply with its sensor. Sensors must be powered and added to the network one at a time.

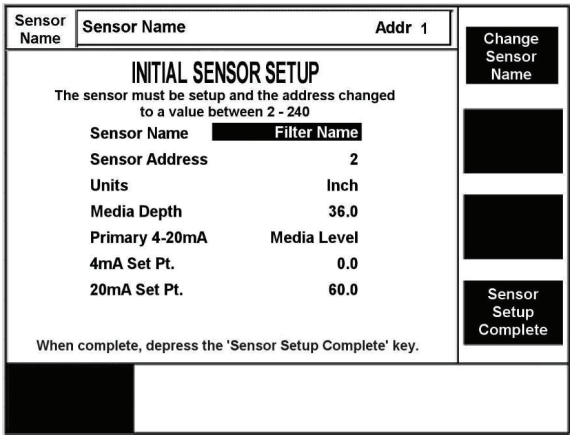
IMPORTANT

Disconnect any outside RS-485 device from the FSC prior to initiating Controller Setup to avoid communication errors.

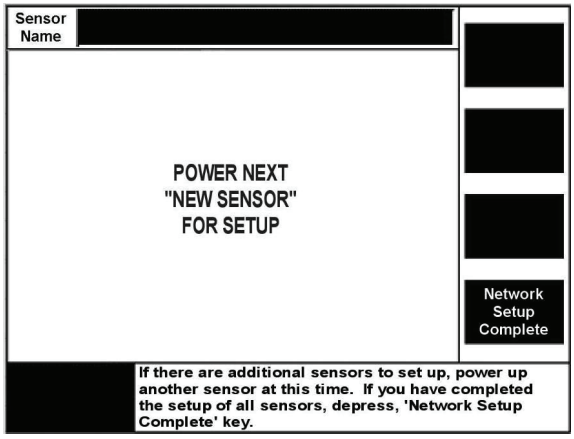
3. From the *Initial Controller Setup* screen, press the **New System Installation** soft key. This routine takes approximately 20 seconds to complete.



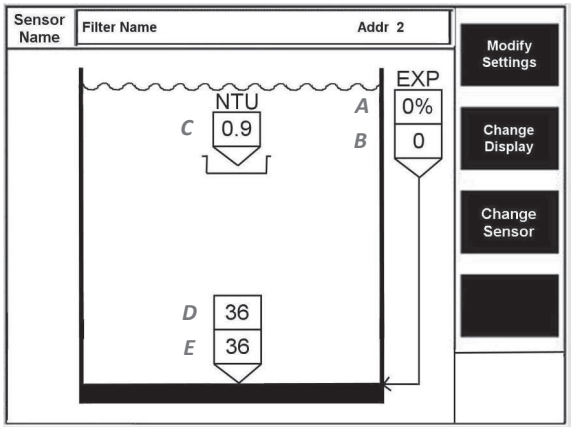
4. Change the *Sensor Address* to a unique value other than 1 and change the *Media Depth* setting to the amount of expandable media in the filter. If using analog outputs, also set the *4…20 mA Set Points* and the desired output for the *Primary 4…20 mA* current loop.



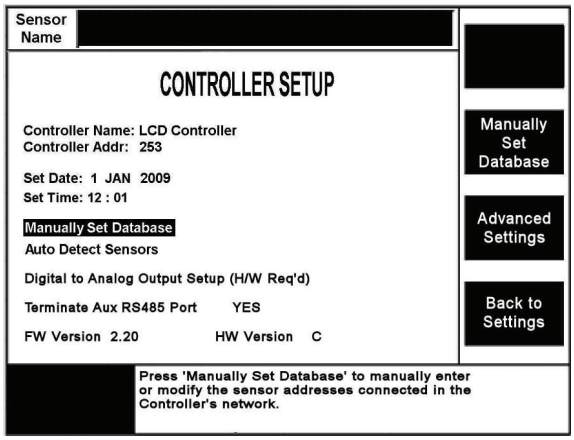
5. When the message "Power Next New Sensor for Setup" displays, apply power to the next sensor to be configured.



6. Repeat steps 4 and 5 for all sensors in the network, making sure that each sensor has a unique *Sensor Address*. When all sensors are set up, press the **Network Setup Complete** soft key.
7. You will be directed to the *Filter View* screen. The sensor goes through an auto-setup initialization process and then begins to report the current measurements.



8. From the *Filter View* screen, press the **Change Display** soft key to see the *Sensor Name*, *Current Media Level*, *Gain Value*, and *Turbidity NTU* of all connected sensors.
9. If a sensor is not automatically found (once powered) during the network setup process or needs to be added later, go to *Modify Settings* > *Controller Setup*, highlight the *Auto Detect Sensors* option and press the **Auto Detect Sensors** soft key.



10. If using an external RS-485 polling device, connect it now. See *"RS-485 Modbus RTU" on page 36* for recommendations and information regarding an RS-485 connection.

Trademarks appearing in this document are the property of their respective entities. Due to continuous research, product improvements and enhancements, Badger Meter reserves the right to change product or system specifications without notice, except to the extent an outstanding contractual obligation exists. © 2025 Badger Meter, Inc. All rights reserved.