VorTek Instruments
FlowCalc™ Flow Computer

Instruction Manual

M-000-0110

Rev 05/2024

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Customer Notice for Oxygen Service

Unless you have specifically ordered VorTek's optional O_2 cleaning, this flow meter may not be fit for oxygen service. Some models can only be properly cleaned during the manufacturing process. VorTek Instruments, LLC., is not liable for any damage or personal injury, whatsoever, resulting from the use of VorTek Instruments standard mass flow meters for oxygen gas.

Specific Conditions of Use

Contact Manufacturer regarding Flame path information.

Clean with a damp cloth to avoid any build-up of electrostatic charge.

Notice to Users

NIST Standard Reference Database 23, NIST Reference Fluid Thermodynamic and Transport Properties: REFPROP Version 9.x. Standard Reference Databases are copyrighted by the U.S. Secretary of Commerce on behalf of the United States of America. All rights reserved. No part of the database may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise without prior permission.

TRADEMARKS
FlowCalc™ is a trademark of VorTek Instruments, LLC. Other product and company names listed in this manual are trademarks or trade names of their respective manufacturers.

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Warnings and Cautions

Warning!

Consult the flow meter nameplate for specific flow meter approvals before any hazardous location installation.

To avoid potential electric shock, follow National Electric Code or your local code when wiring this unit to a power source. Failure to do so could result in injury or death. All AC power connections must be in accordance with published CE directives. All wiring procedures must be performed with the power Off.

Always remove main power before disassembling any part of the flow computer.

Caution!

Firmware updates must be performed by qualified personnel. You must return your flow computer to the factory for firmware updates.

The AC wire insulation temperature rating must meet or exceed 85°C (185°F).

Revision History

Rev. 05/2024

Page Change Description

Chapter 1 Introduction

Multi-Parameter Flow Computer

VorTek Instruments' FlowCalc™ flow computer is a field mounted flow computer which can be used for liquid and gas applications. FlowCalc™ is the most powerful flow computer of its kind and represents some of the latest advancements in operation, performance, and modularity.

FlowCalc™ has been designed to meet the requirements of a wide variety of specialized industries using a single hardware platform thus reducing spare parts requirements, training and calibration costs, and lowers the overall cost of ownership.

When used for differential pressure applications, advanced diagnostic software is able to continually monitor and verify the meter's primary element health and confirm output uncertainty.

The FlowCalc™ product line is available with a wide range of options and configurations to meet your specific application requirements.

Using This Manual

This manual provides information needed to install and operate the FlowCalc™ flow computer.

- Chapter 1 includes the introduction and product description
- Chapter 2 provides information needed for installation
- Chapter 3 describes system operation and programming
- Chapter 4 information on HART, MODBUS, BACnet, and POE protocols

Appendix A - Product Specifications, Appendix B – Approvals, Appendix C – Flow Computer Calculations, Appendix D – Glossary of Terms

Note and Safety Information

We use note, caution and warning statements throughout this book to draw your attention to important information.

Warning!

This statement appears with information that is important to protect people and equipment from damage. Pay very close attention to all warnings that apply to your application.

Caution!

This statement appears with information that is important for protecting your equipment and performance. Read and follow all cautions that apply to your application.

Note

This statement appears with a short message to alert you to an important detail.

Technical Assistance

If you encounter a problem with your flow meter, review the configuration information for each step of the installation, operation and set up procedures. Verify that your settings and adjustments are consistent with factory recommendations.

If the problems occur, contact VorTek Instruments, Technical Support Via Email at Sales@vortekinst.com or by phone at (888) 386-7835 or (303) 682-9999 between 8:00 a.m. and 5:00 p.m. MST. When calling Technical Support, have the following information on hand:

- the serial number and VorTek order number (all marked on the nameplate)
- the problem you are encountering and any corrective action taken
- application information (fluid, pressure, temperature, and piping configuration)

Multivariable Options

The FlowCalc™ model is available with the following options:
VEI, external flow input; VEI-ET external RTD temperature input; VEI-ET-EM energy options with external RTD temperature input.

Flow Computer Electronics

The electronics housing may be used indoors or outdoors, including wet environments. Available input power options are: DC loop powered (2-wire), DC powered, AC powered, or Power over Ethernet. Three analog output signals are available for your choice of three of the five process variables: mass flow rate, volumetric flow rate, temperature, pressure or fluid density. A pulse output signal for remote totalization and MODBUS, HART, BACnet, and IP version of MODBUS/BACnet communications are also available.

FlowCalc™ Flow Computers include a local 2 x 16 character LCD display housed within the enclosure. Local operation and reconfiguration is accomplished using six pushbuttons operated via finger touch. For hazardous locations, the six buttons can be operated with the electronics enclosure sealed using a hand-held magnet, thereby not compromising the integrity of the hazardous location certification.

The electronics include nonvolatile memory that stores all configuration information. The nonvolatile memory allows the flow meter to function immediately upon power up, or after an interruption in power. All flowmeters are calibrated and configured for the customer's flow application.

Chapter 2 Installation

Warning!
To avoid potential electric shock, follow National Electric Code safety practices or your local code when wiring this unit to a power source and to peripheral devices. Failure to do so could result in injury or death. All AC power connections must be in accordance with published CE directives. All wiring procedures must be performed with the power off.

High Power Meter Wiring Connections

The NEMA 4X enclosure contains an integral wiring compartment with one terminal block (located in the smaller end of the enclosure). Two 3/4-inch female NPT conduit entries are available for separate power and signal wiring. For all hazardous area installations, only suitable certified cable glands, blanking plugs or thread adapters may be used. The cable entry device shall be of a certified flameproof type, suitable for the conditions of use and correctly installed. The degree of protection of at least IP66 to EN 60529 is only achieved if certified cable entries are used that are suitable for the application and correctly installed. Unused apertures shall be closed with suitable blanking elements. If conduit seals are used, they must be installed within 18 inches (457 mm) of the enclosure.

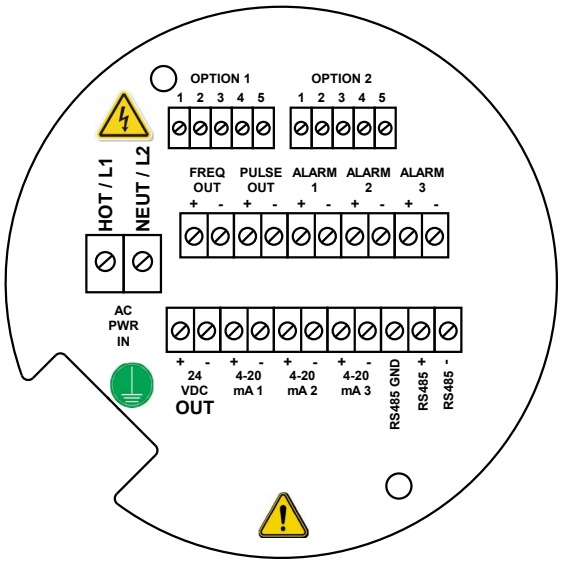


Figure 2.1 - AC Wiring Terminals

Warning!
A power switch is not provided with this meter, an approved switch meeting the power requirements listed in Appendix A must be provided by the user. It must be easily accessible and marked as the disconnect for the flow meter.

Only the connectors supplied with the meter are to be used for connecting wiring.

If the equipment is used in a manner not specified the protection provided by the equipment may be impaired.

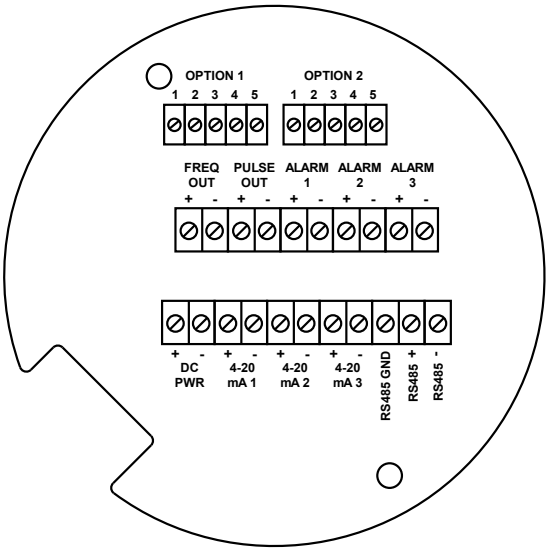


Figure 2.2 - DC Wiring Terminals

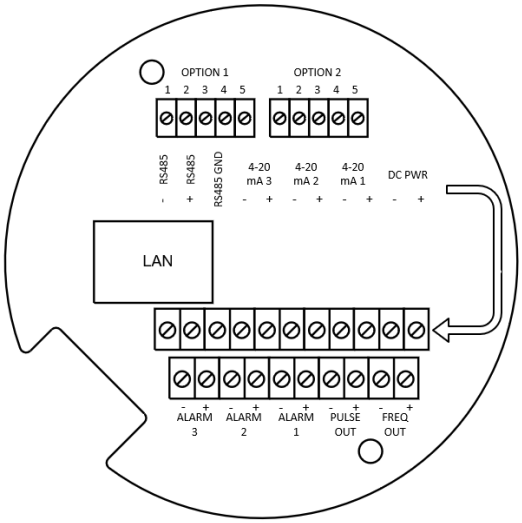


Figure 2.3 - POE Wiring Terminals

Input Power Connections

To access the wiring terminal blocks, locate and loosen the small set screw which locks the small enclosure cover in place. Unscrew the cover to expose the terminal block.

AC Power Wiring

Caution!
The AC wire insulation temperature rating must meet or exceed 90°C (194°F), maximum operating voltage 600 VRMS.

The AC power wire size must be 20 to 10 AWG with the wire stripped 1/4 inch (7 mm). The wire insulation temperature must meet or exceed 90°C (194°F). Connect 100 to 240 VAC (5 W maximum) to the Hot and Neutral terminals on the terminal block. Connect the ground wire to the safety ground lug. Torque all connections to 4.43 to 5.31 in-lbs (0.5 to 0.6 Nm). Use a separate conduit entry for signal lines to reduce the possibility of AC noise interference.

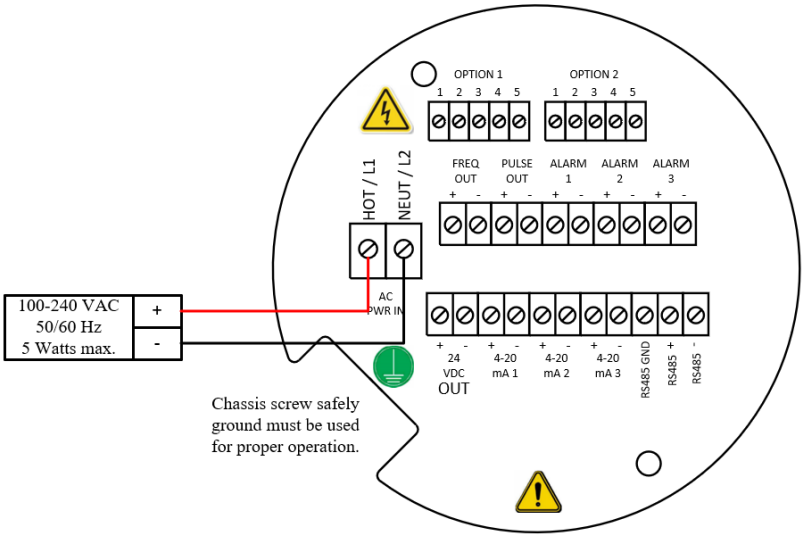


Figure 2.4 - AC Power Connections

DC Power Wiring

Warning!
Use a Class 2 isolated power supply that is grounded, provides DC output, and has no more than 10% output ripple.

A power switch is not provided with this meter, an approved switch meeting the power requirements listed in Appendix A must be provided by the user. It must be easily accessible and marked as the disconnect for the flow meter.

Only the connectors supplied with the meter are to be used for connecting wiring.

If the equipment is used in a manner not specified the protection provided by the equipment may be impaired.

The DC power wire size must be 20 to 12 AWG with the wire stripped 1/4 inch (7 mm). Connect 12 to 36 VDC (300 mA, 9 W maximum) to the +DC Pwr and –DC Pwr terminals on the terminal block.

Torque all connections to 4.43 to 5.31 in-lbs (0.5 to 0.6 Nm).

Alternatively, POE injector may be used for example (TRENDnet TPE-115Gi).

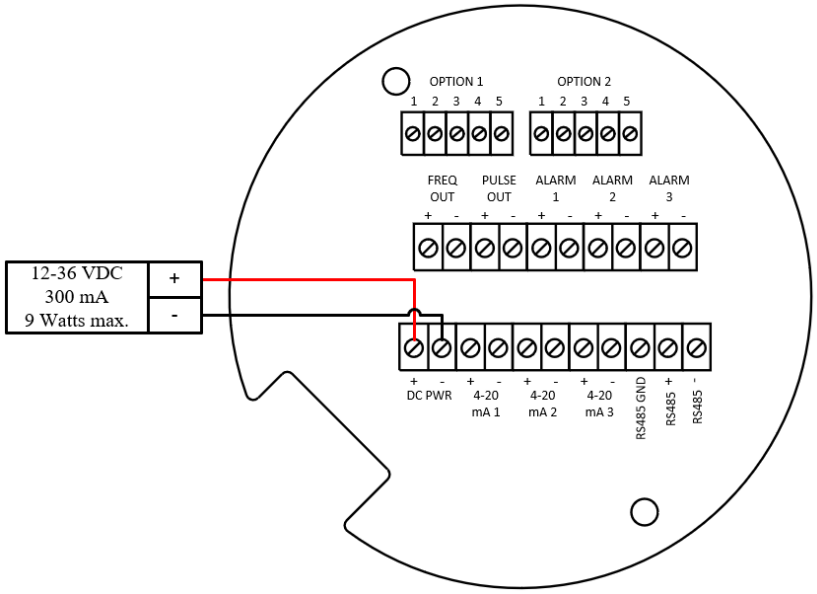


Figure 2.5 - DC Power Connections

Caution!
The DC wire insulation temperature rating must meet or exceed 85°C (185°F), maximum operating voltage 300 VRMS.

Alternatively, POE injector may be used for example (TRENDnet TPE-115Gi).

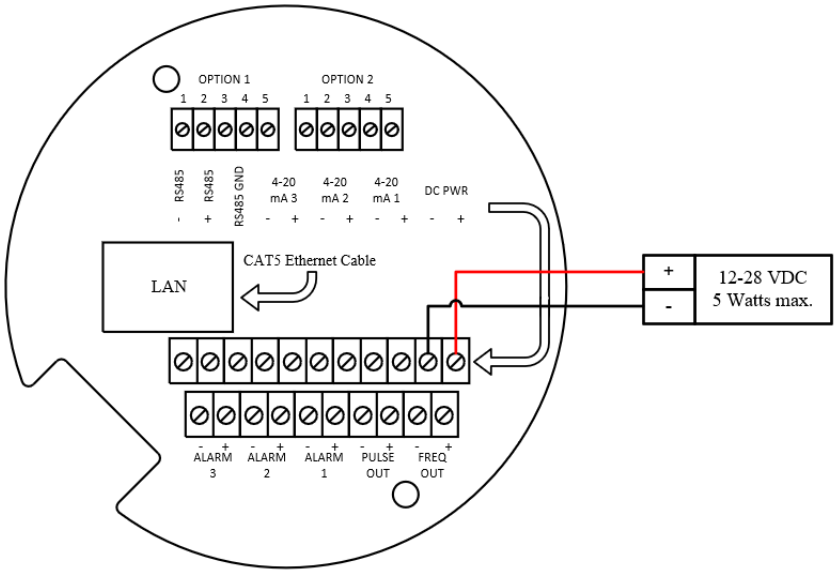


Figure 2.6 - DC POE Power Connections

POE Power Wiring

Connect the unit with the Ethernet cable to POE enable Ethernet switch (POE option does not require a separate power supply).

Plug Ethernet drop off cable from your Local Area Network (LAN) switch to LAN connector of Vortek meter. You should see a blinking orange LED and a solid green on the front of the LAN connector of the meter henCAT5 Ethernet cable is plugged in and communicating.

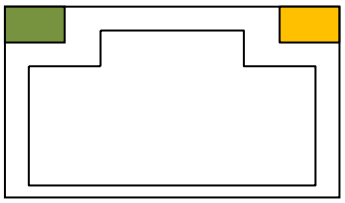


Figure 2.7 - Front of the LAN Connector

4-20 mA Output Connections

The DC wire insulation temperature rating must meet or exceed 85°C (185°F), maximum operating voltage 300 VRMS operate correctly.

The maximum loop resistance (load) for the current loop output is dependent upon the supply voltage and is given in Figure 2.8. The 4-20 mA loop is optically isolated from the flow meter electronics.

R_{load} is the total resistance in the loop, including the wiring resistance ($R_{load} = R_{wire} + R_{sense}$). To calculate R_{max}, the maximum R_{load} for the loop, subtract the minimum terminal voltage from the supply voltage and divide by the maximum loop current, 20 mA. Thus:

The maximum resistance $R_{load} = R_{max} = (V_{supply} – 12V) / 0.020$ A

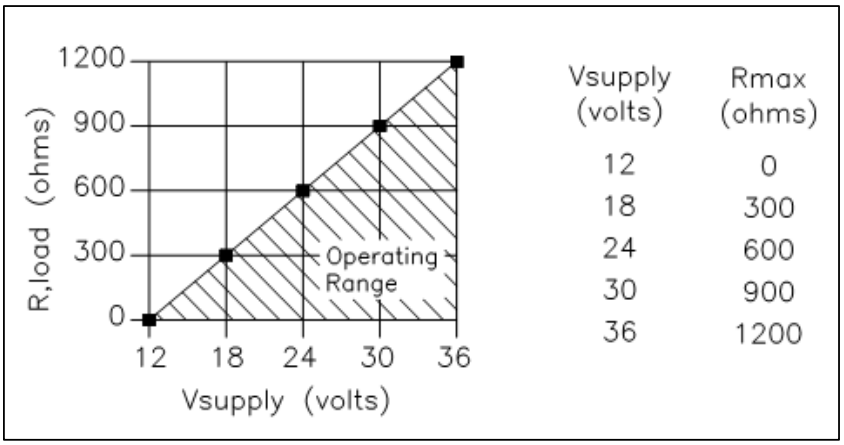


Figure 2.8 - Load Resistance Versus Input Voltage

The current loop range is 3.8 to 20.5 mA. See Figures 2-9 through 2-12 for wiring options.

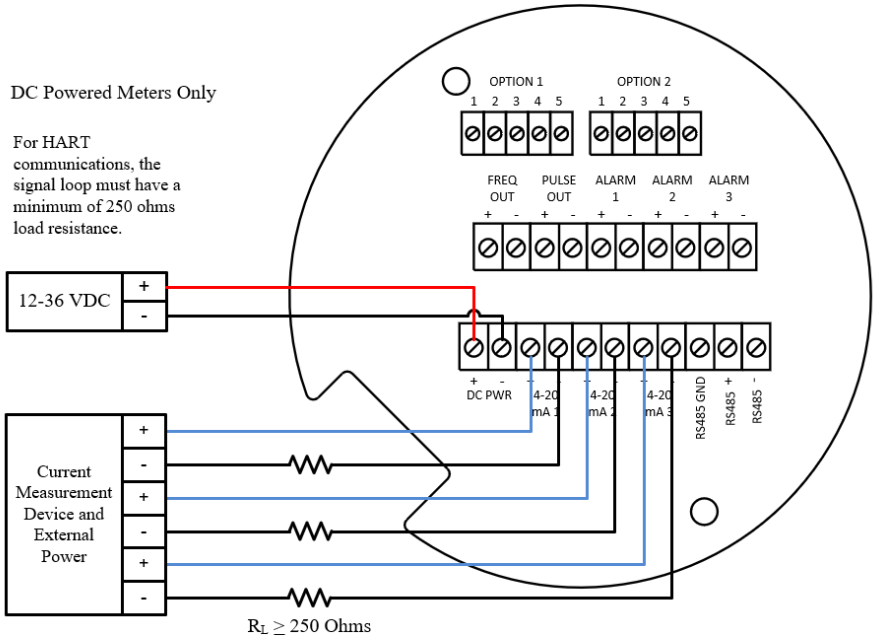


Figure 2.9 - Isolated 4-20mA Output Using External Power Supply

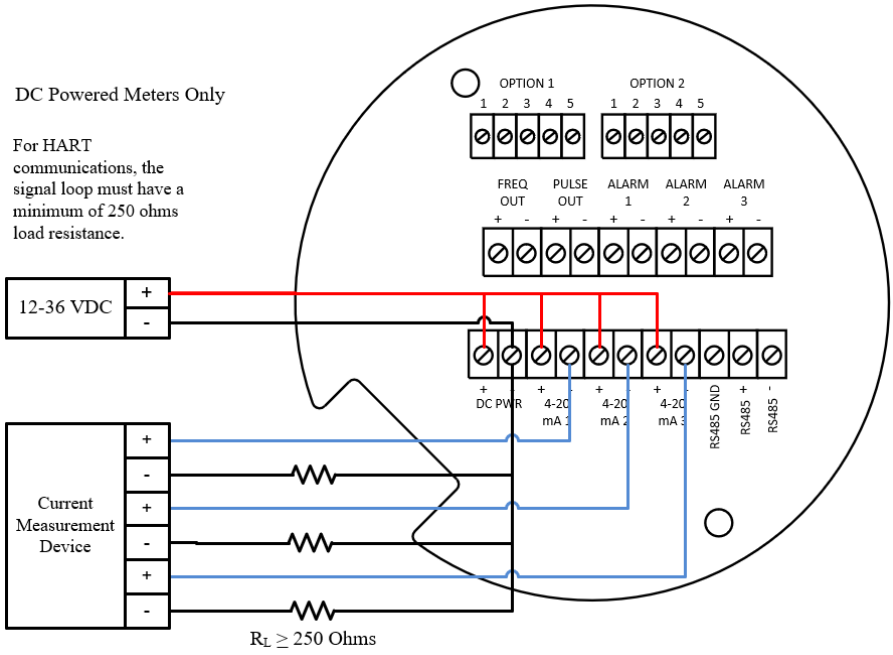


Figure 2.10 – Non-Isolated 4-20 mA Output Using Meter Input Power Supply

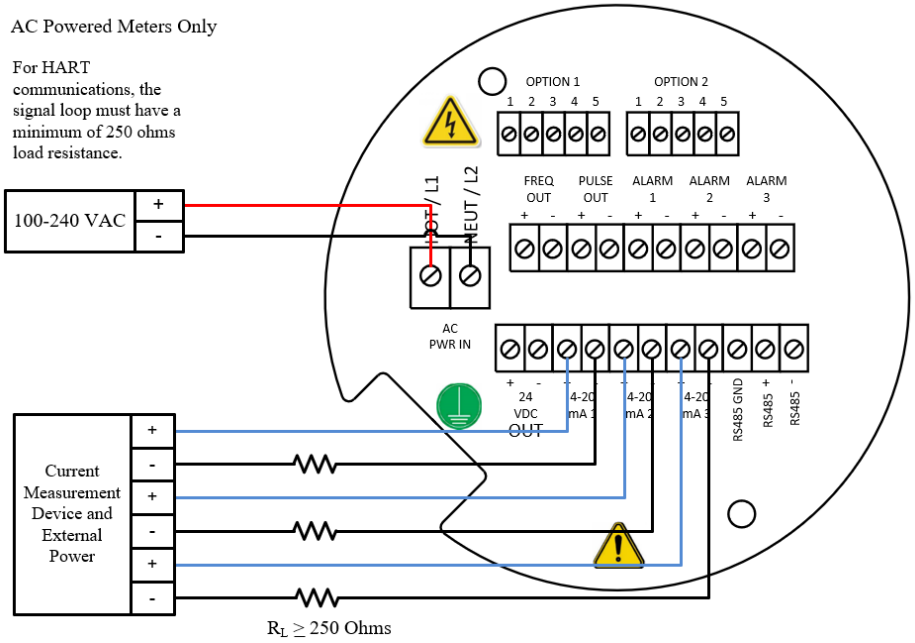


Figure 2.11 - Isolated 4-20 mA Output Using External Power Supply

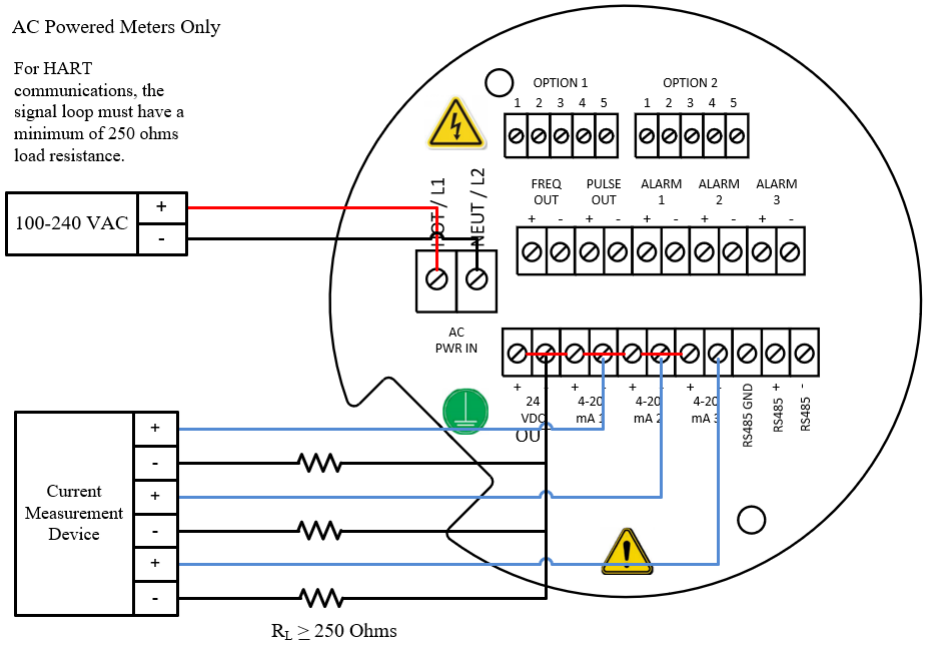


Figure 2.12 – Isolated 4-20 mA Output Using Meter Provided Power Supply

Pulse Output Connections

The pulse output is used for a remote counter. When the preset volume or mass (defined in the totalizer settings, see page 38) has passed the meter, the output provides a 50 millisecond square pulse.

The pulse output requires a separate 5 to 36 VDC power supply. The pulse output optical relay is a normally-open single-pole relay. The relay can conduct a current up to 40 mA. It is isolated from the meter electronics and power supply.

There are three connection options for the pulse output – the first with a separate power supply (Figures 2-13 and 2-15), the second using the flow meter power supply (Figure 2-14)(DC powered units only), and the third using the internal 24 VDC power supply (Figure 2-16)(AC powered units only). Use the first option with a separate power supply (5 to 36 VDC) if a specific voltage is needed for the pulse output. Use the second configuration if the voltage at the flow meter power supply is an acceptable driver voltage for the load connected. (Take into account that the current used by the pulse load comes from the meter's power supply). Use the third configuration if you have an AC powered unit only. In any case, the voltage of the pulse output is the same as the voltage supplied to the circuit.

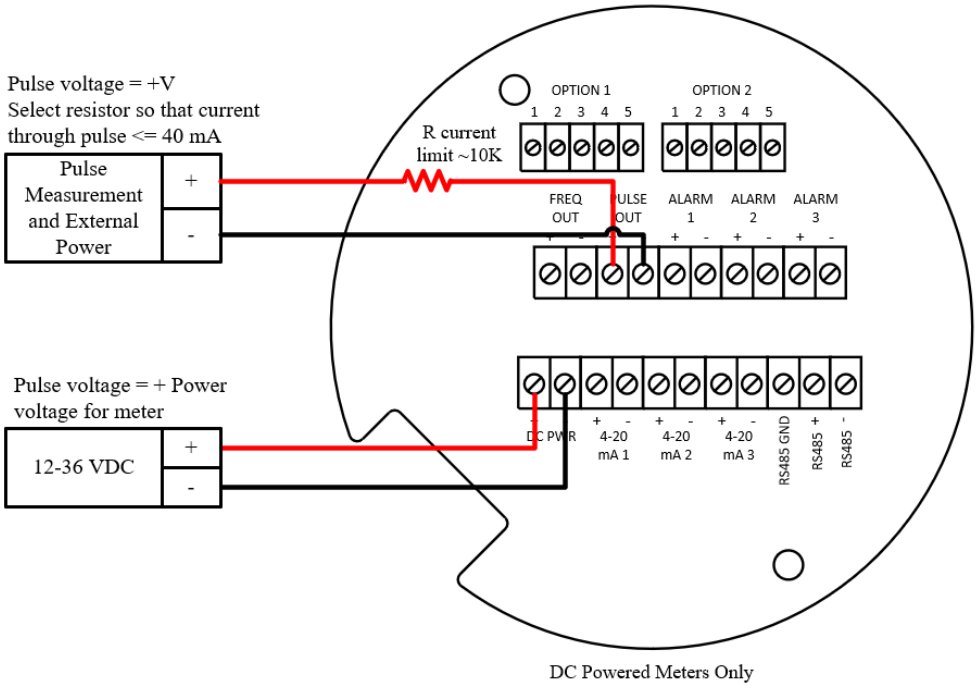


Figure 2.13 - Isolated Pulse Output Using External Power Supply

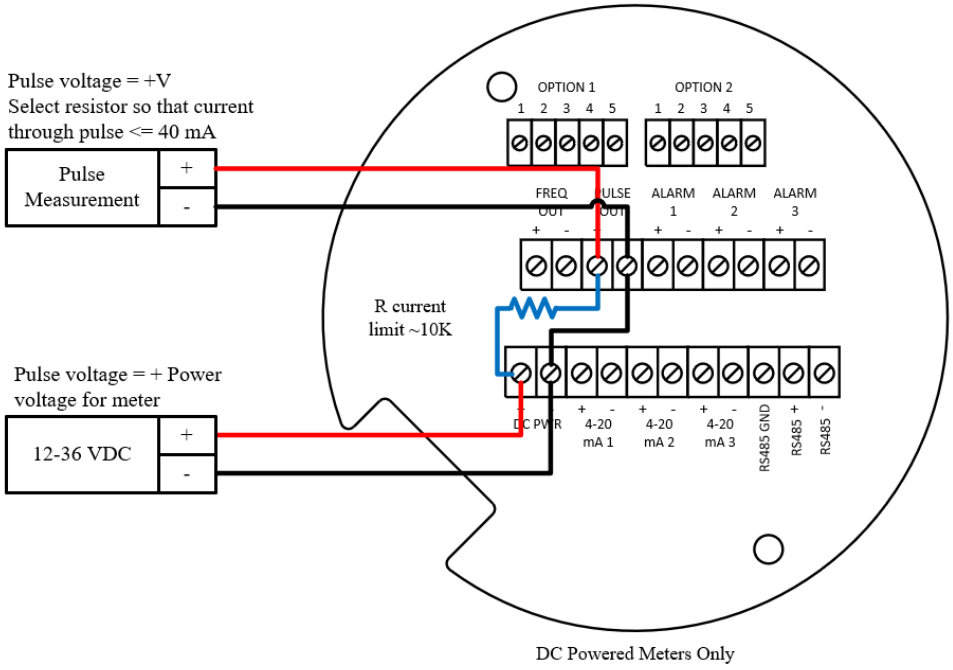


Figure 2.14 – Non-Isolated Pulse Output Using Input Power Supply

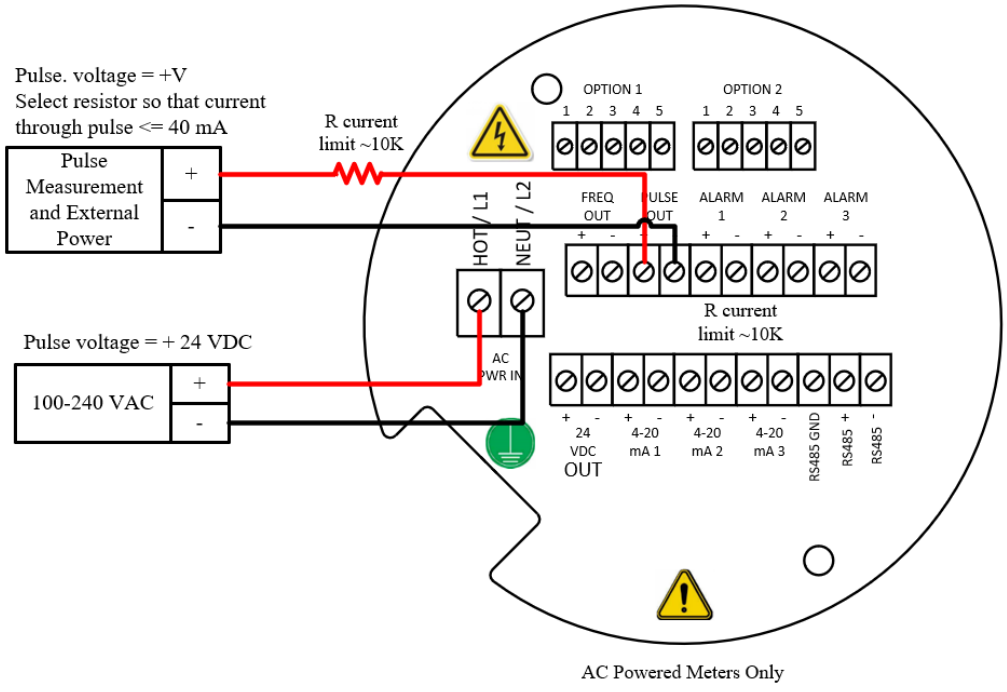


Figure 2.15 - Isolated Pulse Output Using External Power Supply

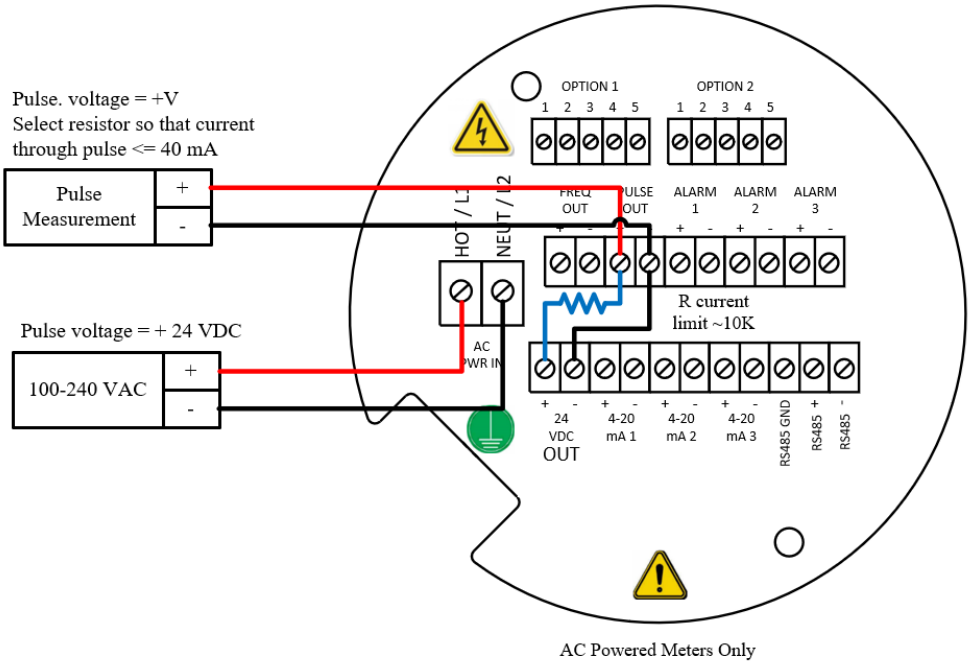


Figure 2.16 – Isolated Pulse Output Using Meter Provided Power Supply

Frequency Output Connections

The frequency output is used for a remote counter. It can be scaled to output a 1 to 10 kHz signal proportional to mass or volume flow, temperature, pressure, or density. Scaled frequency will need to be set in the Output Menu (see page 36).

The frequency output requires a separate 5 to 36 VDC power supply. The frequency output optical relay is a normally-open single-pole relay. The output can conduct a current up to 40 mA. It is isolated from the meter electronics and power supply.

There are three connection options for the frequency output – the first with a separate power supply (Figures 2-17 and 2-19), the second using the flow meter power supply (Figure 2-18)(DC powered units only), and the third using the internal 24 VDC power supply (Figure 2-20)(AC powered units only). Use the first option with a separate power supply (5 to 36 VDC) if a specific voltage is needed for the frequency output. Use the second configuration if the voltage at the flow meter power supply is an acceptable driver voltage for the load connected. (Take into account that the current used by the frequency load comes from the meter's power supply). Use the third configuration if you have an AC powered unit only. In any case, the voltage of the frequency output is the same as the voltage supplied to the circuit.

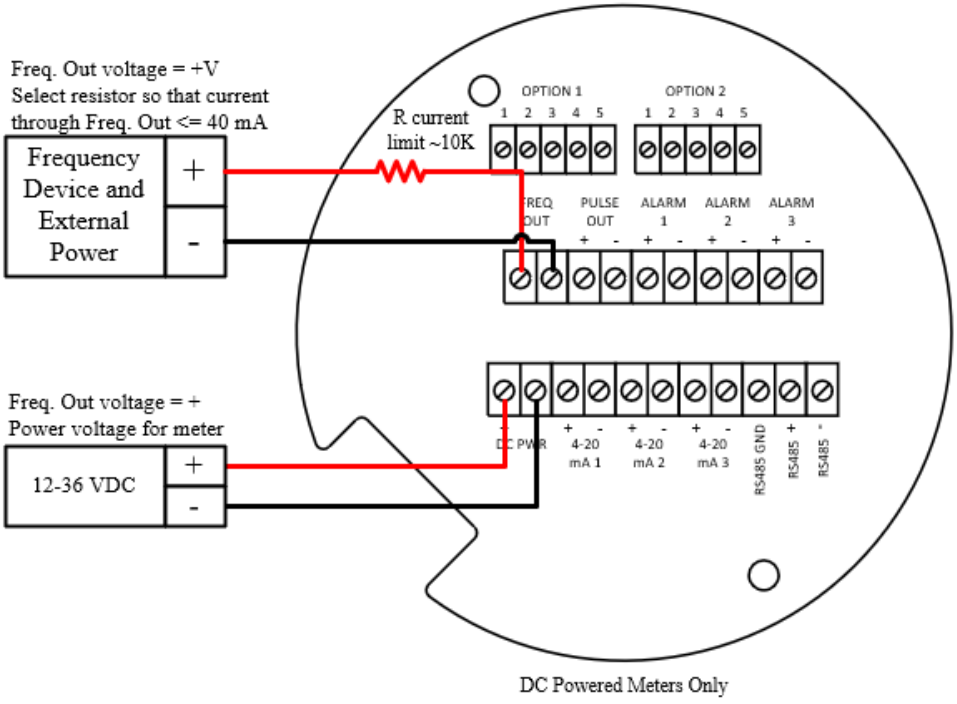


Figure 2.17 - Isolated Frequency Output Using External Power Supply

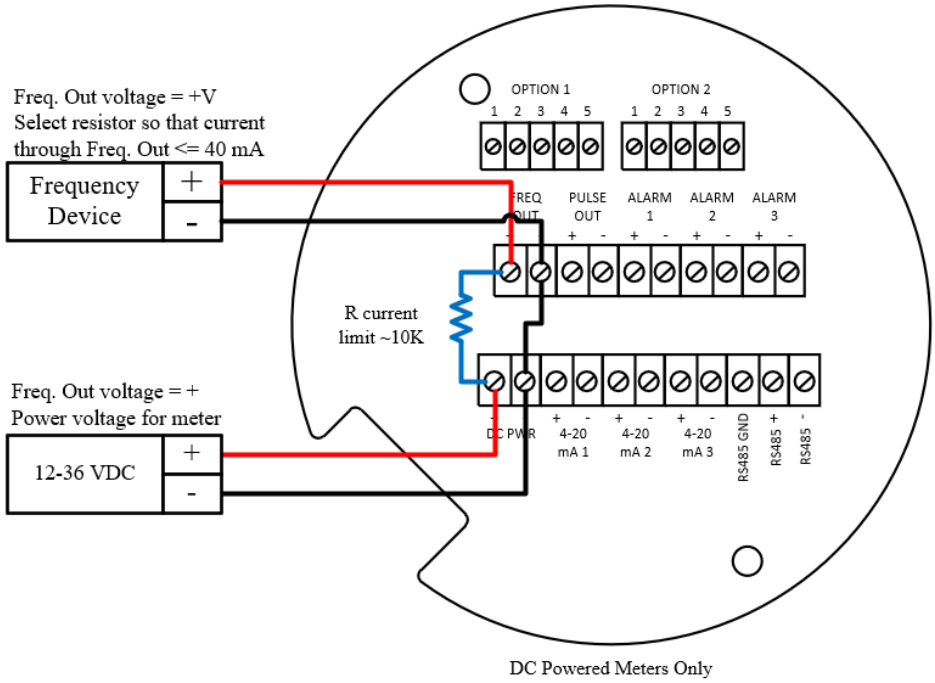


Figure 2.18 – Non-Isolated Frequency Output Using Input Power Supply

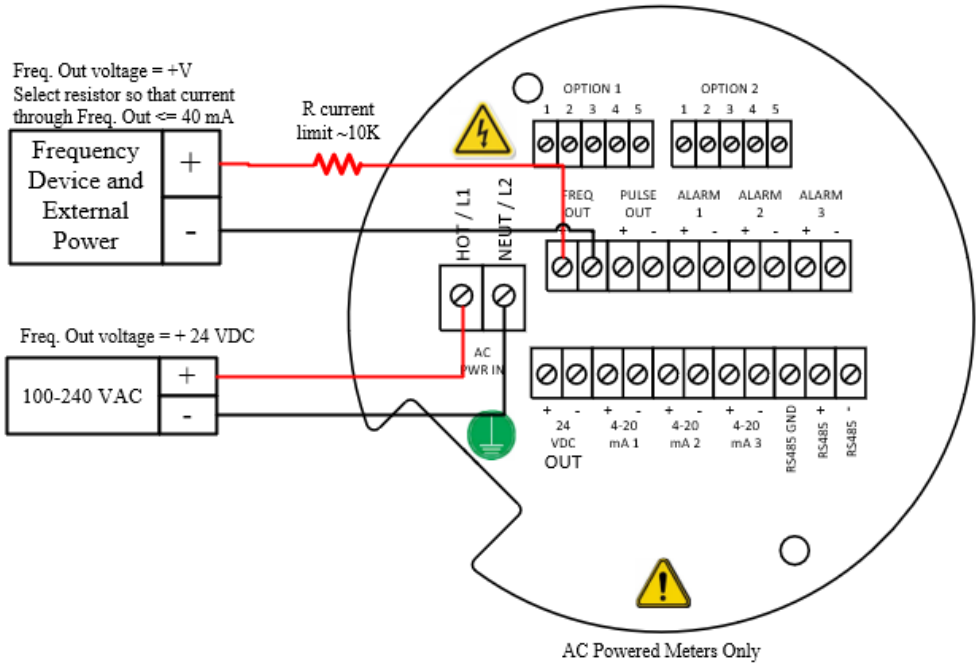


Figure 2.19 - Isolated Frequency Output Using External Power Supply

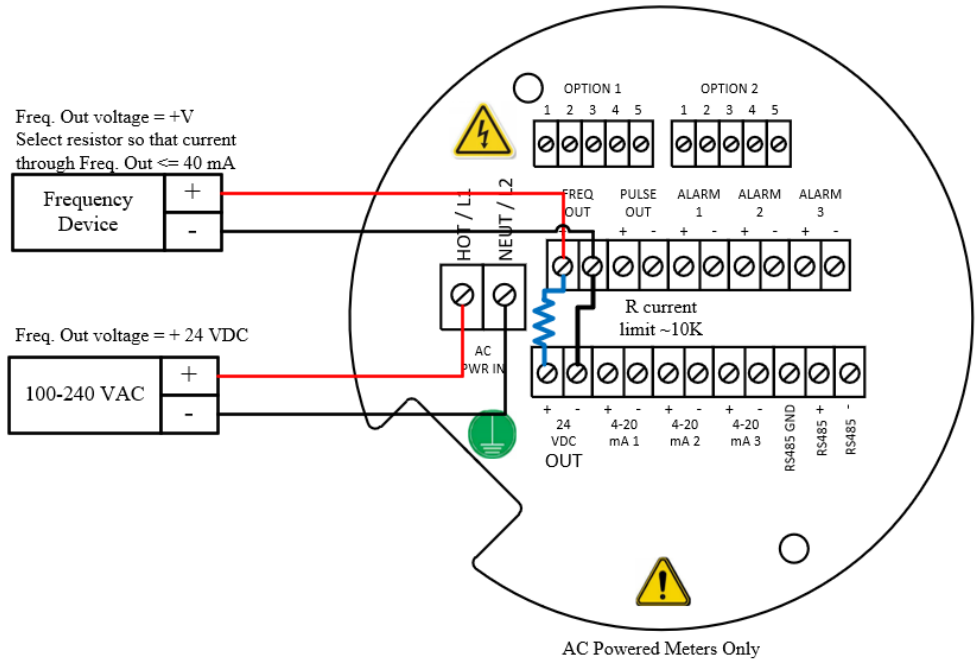


Figure 2.20 – Non-Isolated Frequency Output Using Meter Provided Power Supply

Alarm Output Connections

One alarm output (Alarm 1) is included on the standard FlowCalc™ Flow Computer. Two or more alarms (Alarm 2 and Alarm 3) are included on the optional communication board. The alarm output requires a separate 5 to 36 VDC power supply. The alarm output optical relay is a normally-open single-pole relay. The relay can conduct a current up to 40 mA. It is isolated from the meter electronics and power supply. When the alarm relay is closed, the current draw will be constant. Make sure to size R_{load} appropriately.

There are three connection options for the alarm output–the first with a separate power supply (Figures 2-21 and 2-23), the second using the flow meter power supply (Figure 2-22)(DC powered units only) and the third with the meter provided power supply (Figure 2-24)(AC powered units only). Use the first option with a separate power supply (5 to 36 VDC) if a specific voltage is needed for the alarm output. Use the second configuration if the voltage at the flow meter power supply is an acceptable driver voltage for the load connected. (Take into account that the current used by the alarm load comes from the meter's power supply). Use the third if you have an AC powered unit only. In any case, the voltage of the alarm output is the same as the voltage supplied to the circuit.

The alarm output is used for transmitting high or low process conditions as defined in the alarm settings (see page 40).

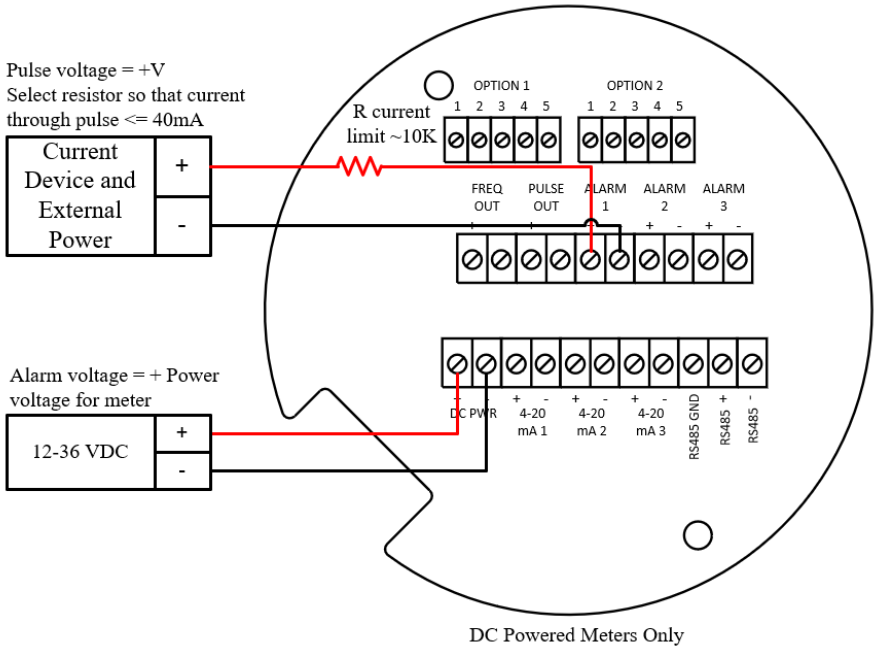


Figure 2.21 - Isolated Alarm Output Using External Power Supply

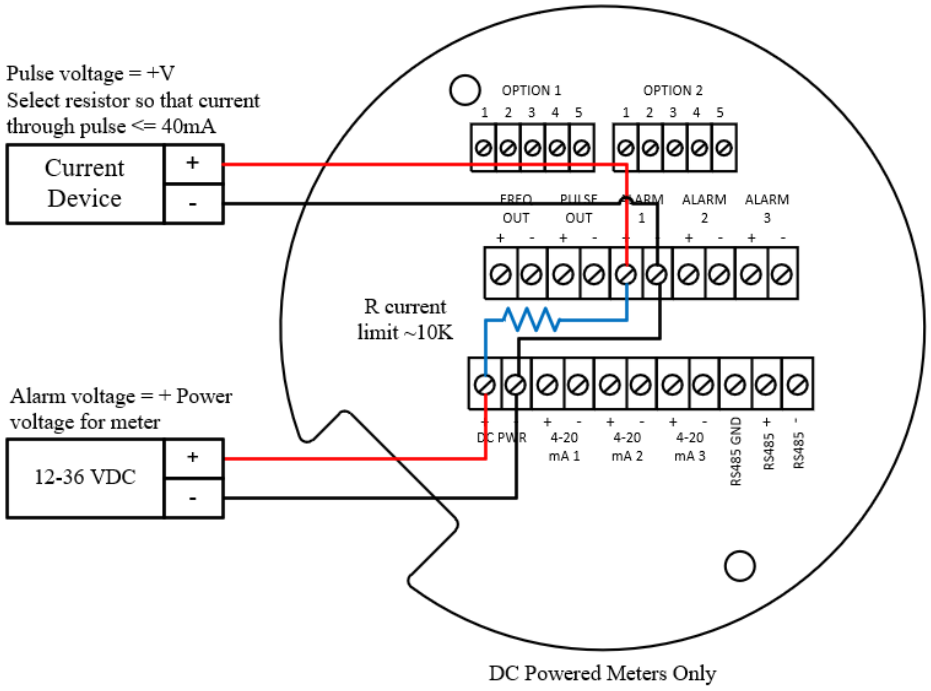


Figure 2.22 – Non-Isolated Alarm Output Using Internal Power Supply

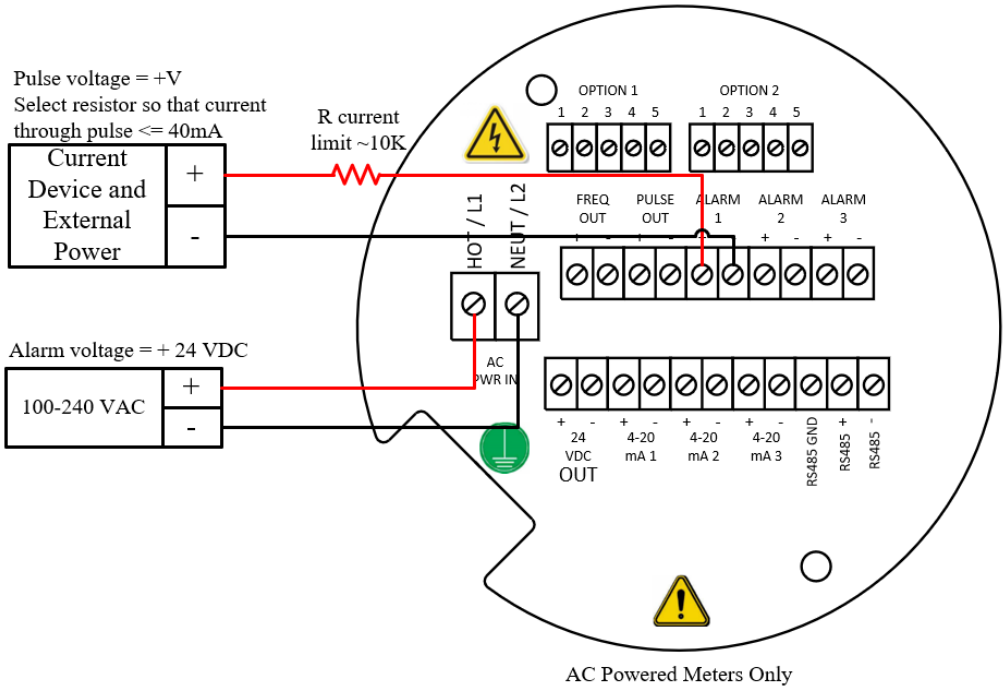


Figure 2.23 - Isolated Alarm Output Using External Power Supply

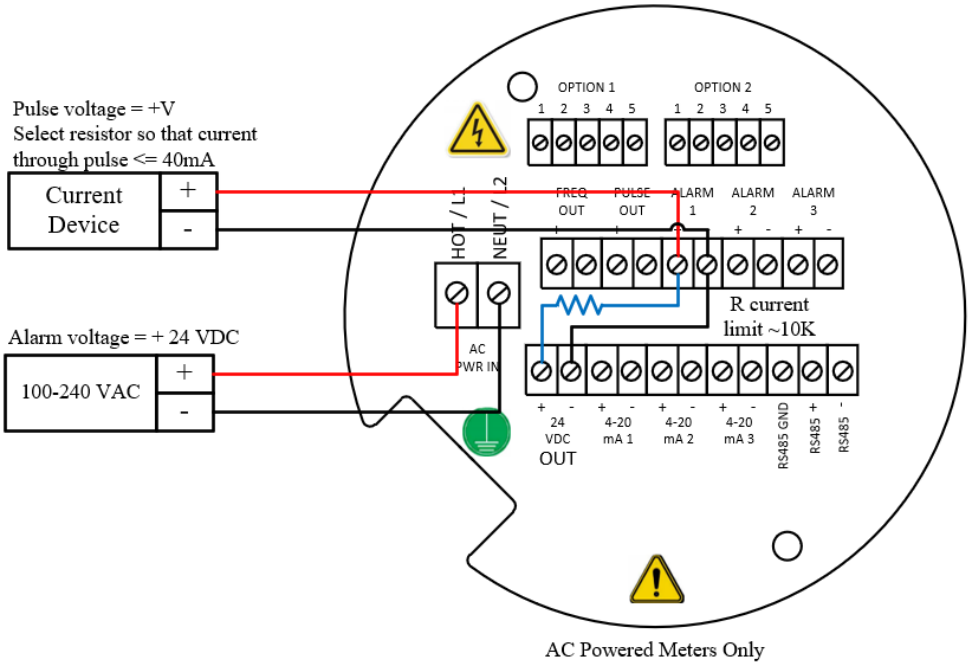


Figure 2.24 – Non-Isolated Alarm Output Using Meter Provided Power Supply

Optional Input Electronics Wiring

The meter has two optional input wiring terminals, maximum wire size is 16 AWG. These can be used to input a Remote or Second RTD input in the case of an Energy Monitoring meter, for the input of a Remote Pressure Transducer, to pass a Contact Closure or for a Remote Density measurement to name a few. In any case, the wiring diagram will be included with the meter if any of the options are specified. Otherwise, the optional terminal blocks will be left blank and nonfunctional.

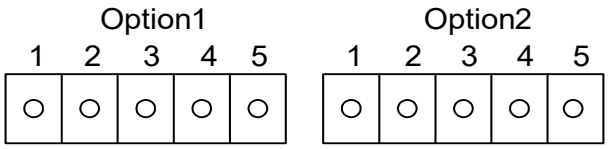


Figure 2.25 - Optional Terminal Blocks

Optional Energy EMS RTD Input Wiring

High Power

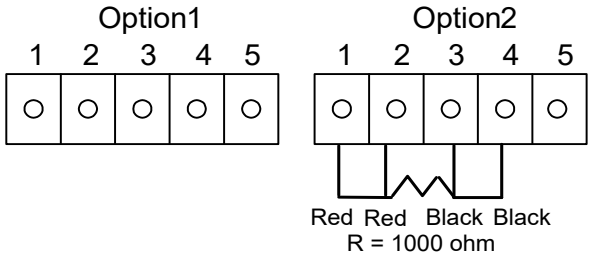


Figure 2.26 - High Power EMS RTD

The recommended customer supplied second RTD is a Class A 1000 ohm 4-wire platinum RTD. If a second RTD is not being used, then the factory supplied 1000 ohm resistor needs to be installed in its place.

Optional External 4-20 mA Input Wiring

The meter is set to have Option 1 used for the external input. Programming menus that pertain to the optional 4-20 mA input are located in the Hidden Diagnostics Menu in Chapter 5.

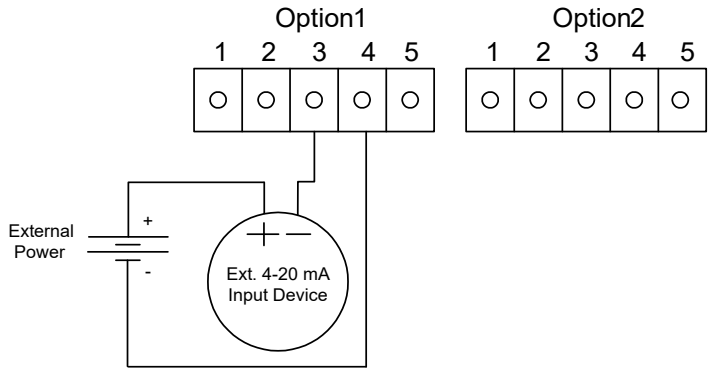


Figure 2.27 - External 4-20 mA Input Wiring - External Power Supply

Follow the above diagram to wire the external 4-20 mA input into the flow meter using an external power supply.

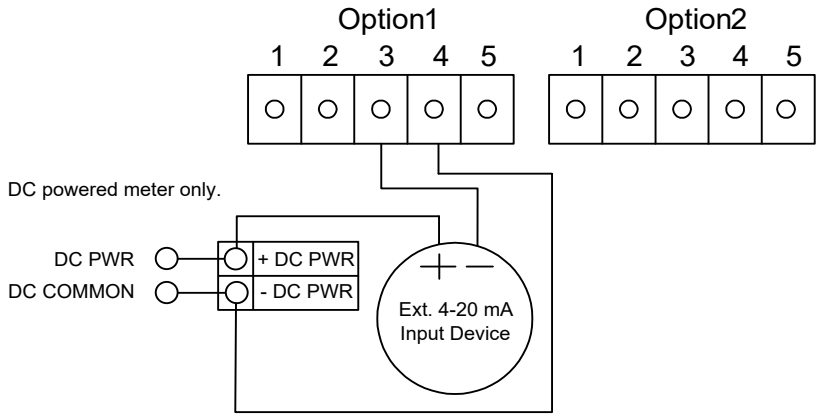


Figure 2.28 - External 4-20 mA Input Wiring - DC Powered Meter

Follow the above diagram to wire the external 4-20 mA input into the flow meter using power supplied to the input of a DC powered meter.

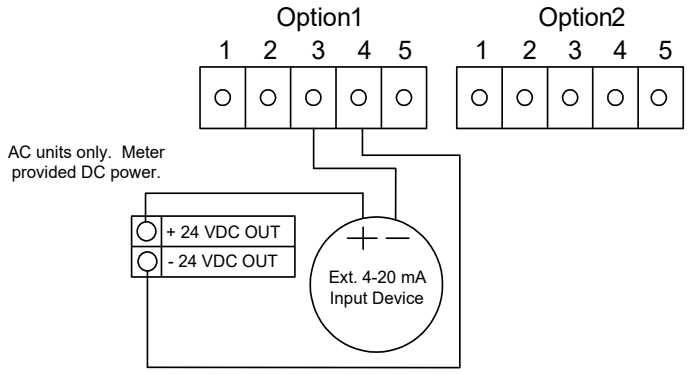


Figure 2.29 - External 4-20 mA Input Wiring - AC Powered Meter

Follow the above diagram to wire the external 4-20 mA input into the flow meter using power from the 24 VDC output of an AC powered meter.

Optional External 4-20 mA Input and RTD Wiring

High Power

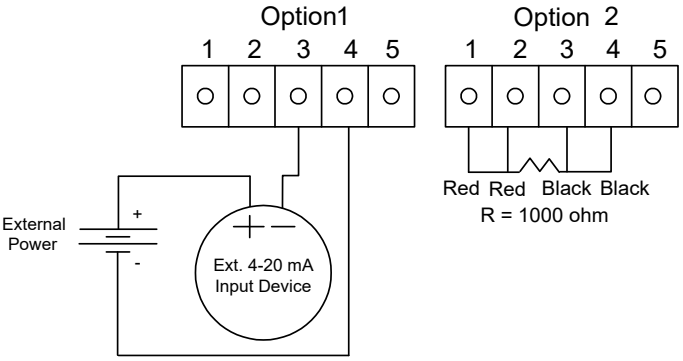


Figure 2.30 - External 4-20 mA Input and RTD Wiring - High Power

Optional Energy EMS External 4-20 mA Input and RTD Wiring

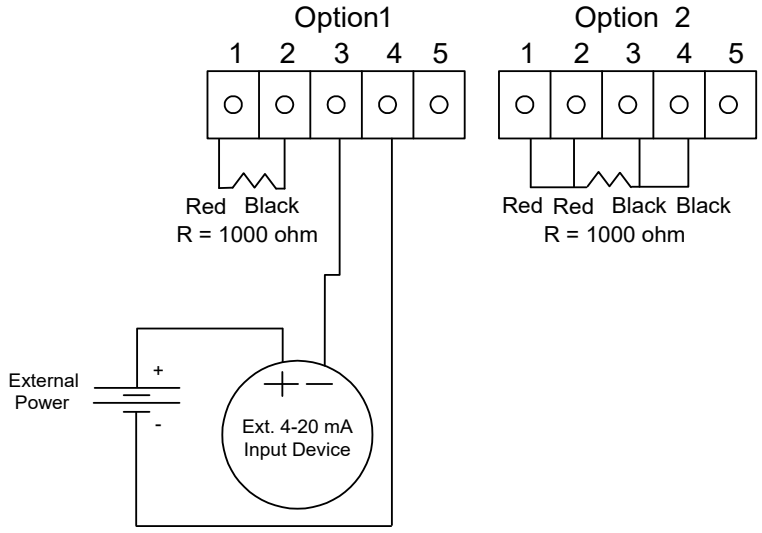


Figure 2.31 - Energy EMS External 4-20 mA Input and RTD Wiring - High Power

Optional External Contact Closure Input Wiring

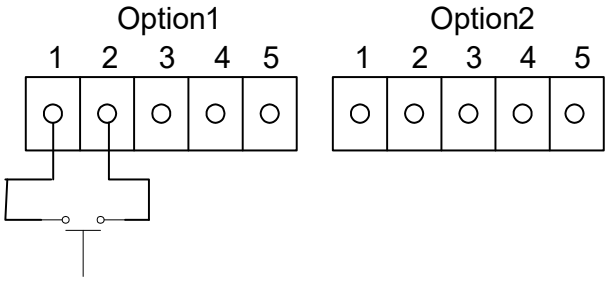


Figure 2.32 - Optional External Contact Closure Input Wiring

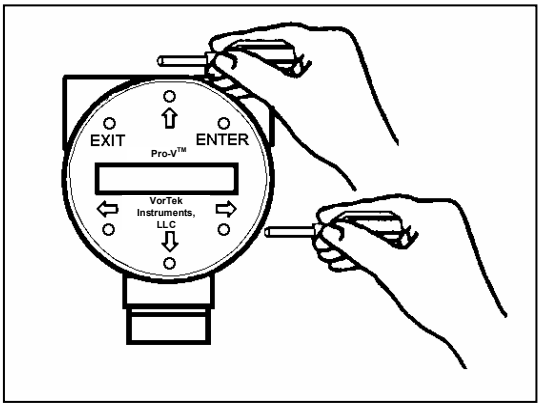
Follow the above diagram to wire an external switch input into the flow meter. The meter is configured to have Option 1 used for the external input. If the above switch is used to remotely reset the totalizer a pushbutton switch with a momentary contact closure is recommended.

Chapter 3 Operating Instructions

Warning!
Do not open covers when an explosive atmosphere may be present.

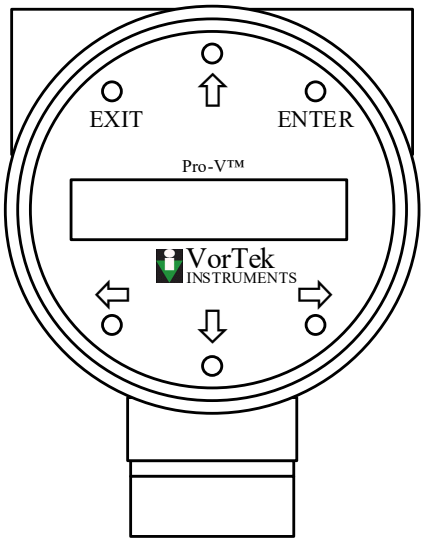
After installing the FlowCalc™ Flow Computer, you are ready to begin operation. The sections in this chapter explain the display/keypad commands, meter start-up and programming. The meter is ready to operate at start up without any special programming. To enter parameters and system settings unique to your operation, see the following pages for instructions on using the setup menus.

Flow Computer Display/Keypad



The flow meter's digital electronics allow you to set, adjust and monitor system parameters and performance. A full range of commands are available through the display/keypad. The LCD display gives 2 x 16 characters for flow monitoring and programming. The six push-buttons can be operated with the enclosure cover removed. Or, the explosion-proof cover can remain in place and the keypad operated with a hand-held magnet positioned at the side of the enclosure as shown in the illustration at the left. To secure the enclosure cover use a 1/16" hex key wrench to tighten the 6-32 x 1/4 cup point socket set locking screw.

Display/Keypad Commands



From the Run Mode, the **ENTER** key allows access to the Setup Menus (through a password screen). Within the Setup Menus, pressing **ENTER** activates the current field. To set new parameters, press the **ENTER** key until an underline cursor appears. Use the ⇧⇩⇦⇨ keys to select new parameters. Press **ENTER** to continue (If change is not allowed, **ENTER** has no effect). All outputs are disabled when using the Setup Menus.

The **EXIT** key is active within the Setup Menus. When using a Setup Menu, **EXIT** returns you to the Run Mode. If you are changing a parameter and make a mistake, **EXIT** allows you to start over.

The ⇧⇩⇦⇨ keys advance through each screen of the current menu. When changing a system parameter, all ⇧⇩⇦⇨ keys are available to enter new parameters.

Figure 3.1 - Flow Meter Display/Keypad

Display Contrast Adjustment

The flow computer display contrast is set at the factory but if the display characters appear too dark or too light proceed as follows:

1. Hold down the "Exit" button on the front panel for 5 to 10 seconds. "Setting Contrast" will appear.

2. Push the "Up" arrow to darken the display or the "Down" arrow to lighten it.

3. Push the "Enter" button to save the contrast setting.

Start-Up

To begin flow computer operation:

Note

Starting the flow meter or pressing EXIT will always display the Run Mode screens.

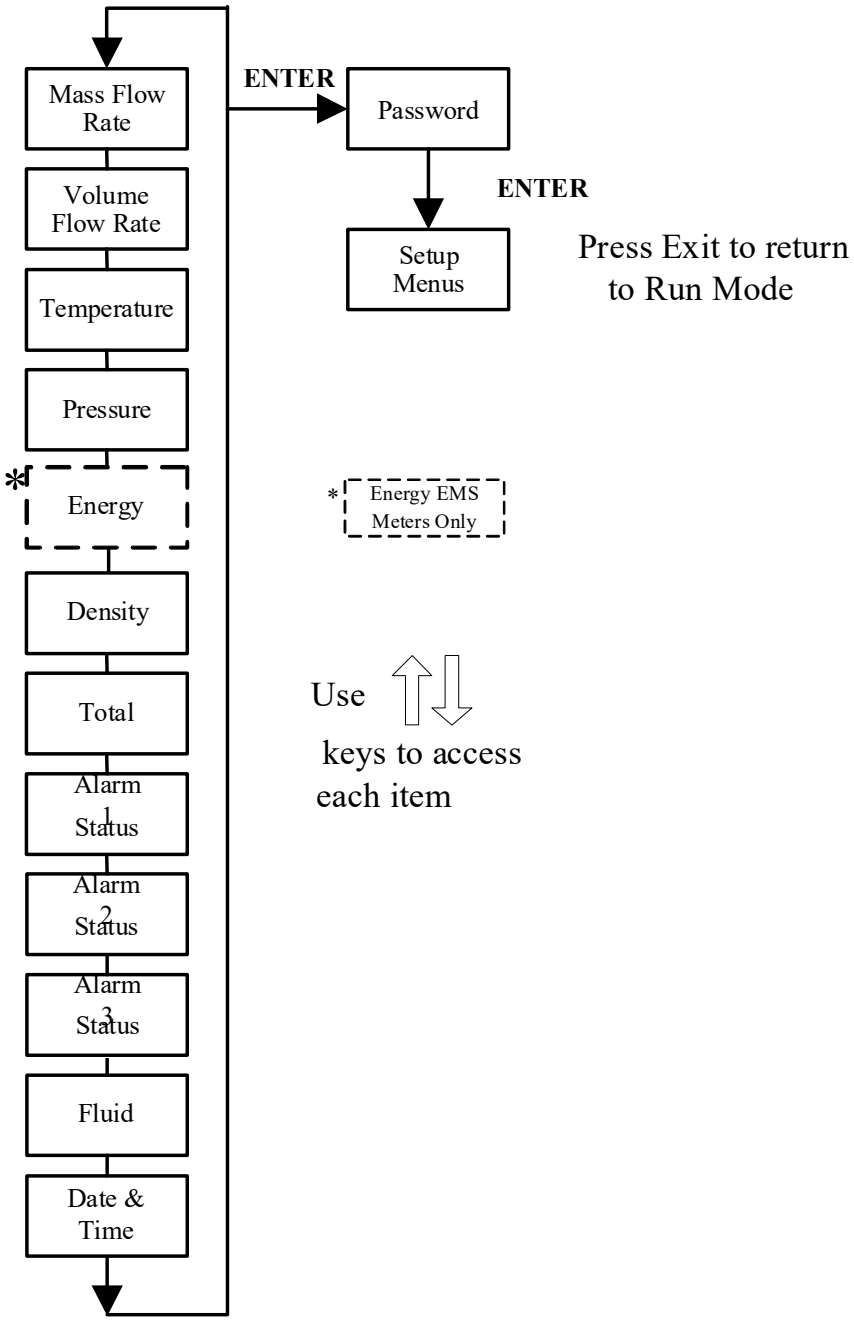
1. Verify the flow computer is installed and wired as described in Chapter 2.

2. Apply power to the meter. At start up, the unit runs a series of self-tests that check the RAM, ROM, EPROM and all flow sensing components. After completing the self-test sequence, the Run Mode screens appear.

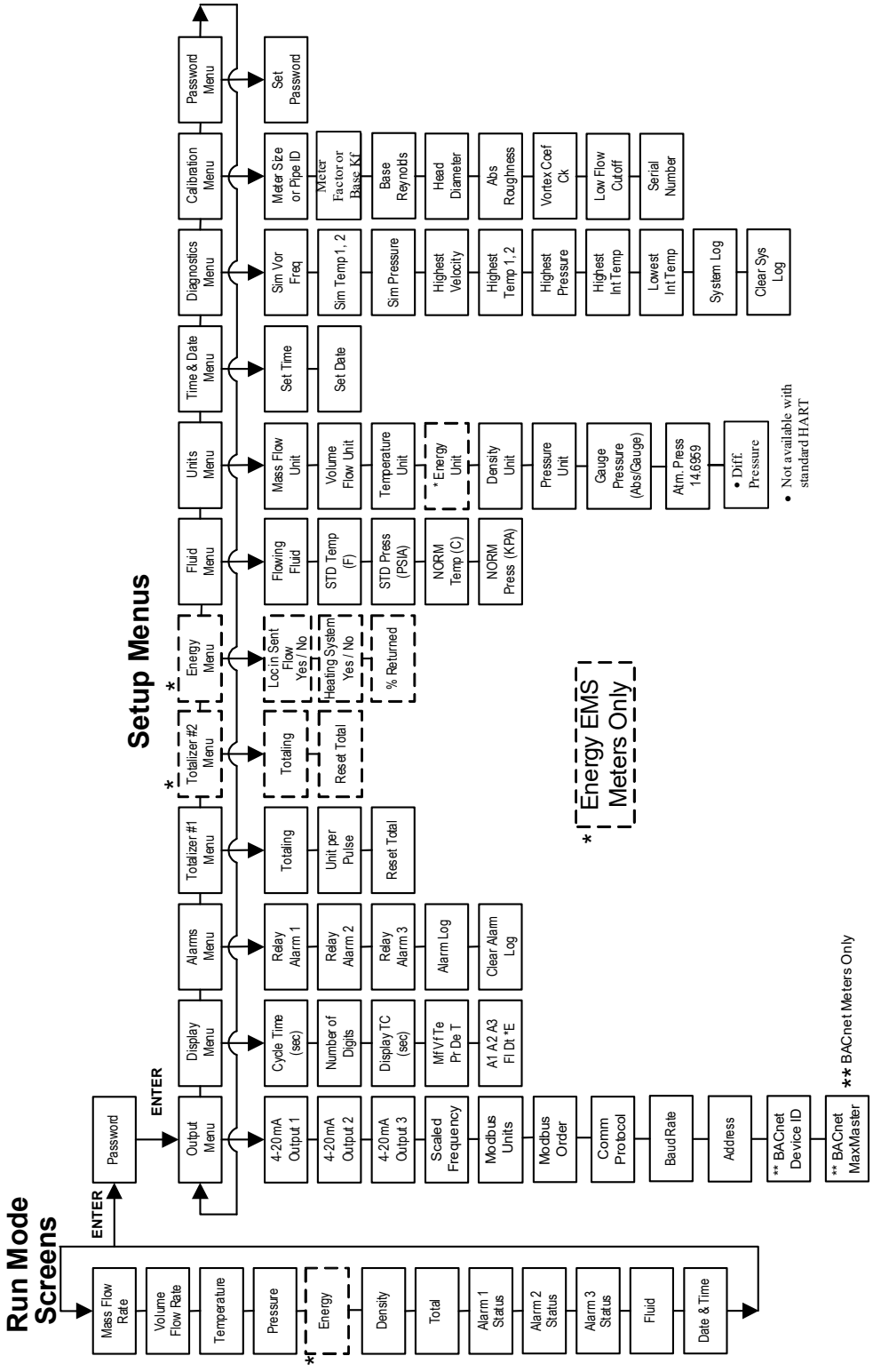
3. The Run Mode displays flow information as determined by system settings. Some screens depicted on the next page may not be displayed based on these settings. Press the ⇧⇩ arrow keys to view the Run Mode screens.

4. Press the ENTER key from any Run Mode screen to access the Setup Menus. Use the Setup Menus to configure the computer's multi-parameter features to fit your application.

Run Mode Screens



Using the Setup Menus



Programming the Flow Computer

1. Enter the Setup Menu by pressing the ENTER key until prompted for a password. (All outputs are disabled while using the Setup Menus.)

2. Use the ⇧⇩⇦⇨ keys to select the password characters (1234 is the factory-set password). When the password is correctly displayed, press ENTER to continue.

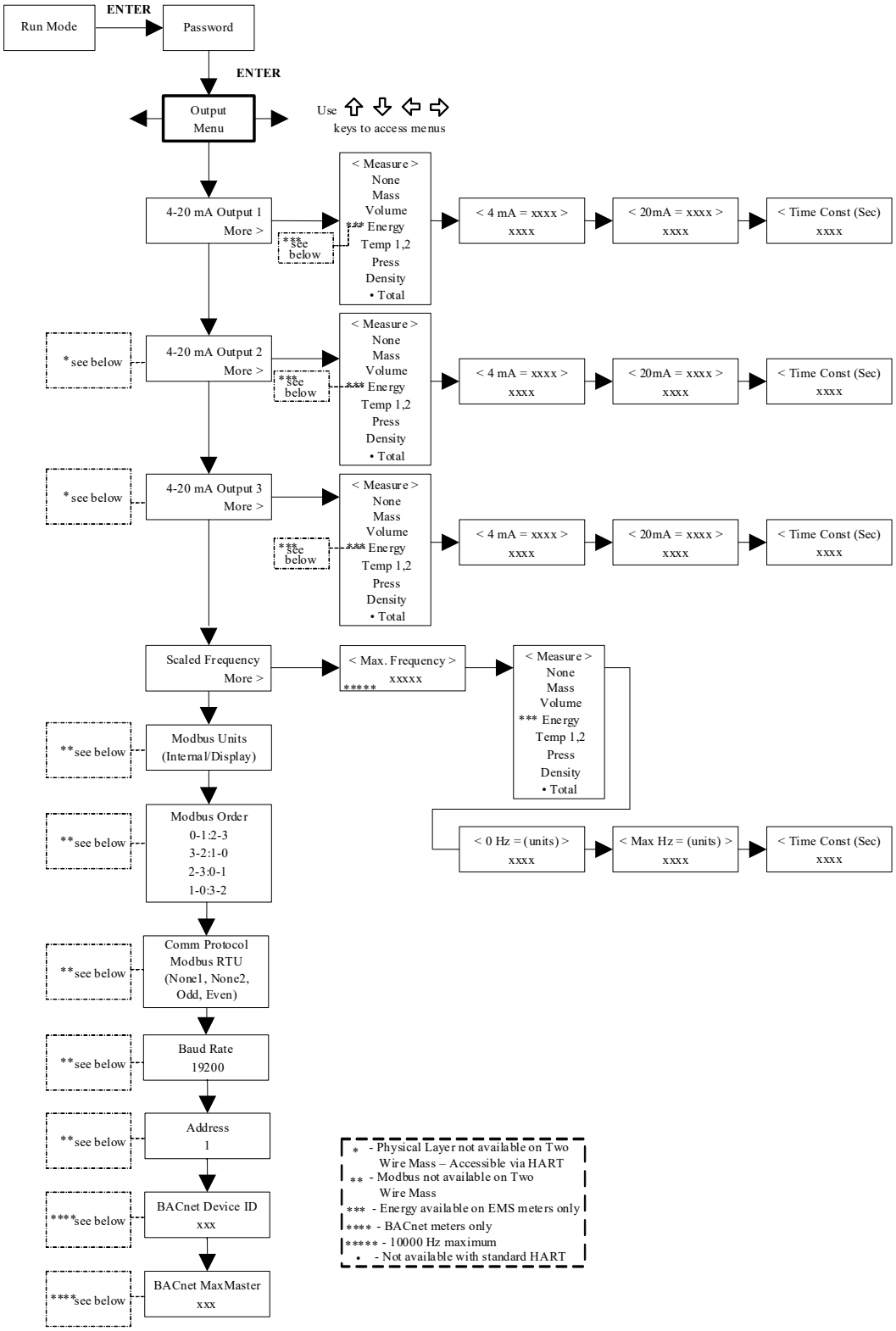
3. Use the Setup Menus described on the following pages to customize the multi-parameter features of your FlowCalc™ Flow Computer. (The entire lower display line is available for entering parameters.) Some items depicted in the graphic on the preceding page may not be displayed based on flow computer configuration settings.

4. To activate a parameter, press ENTER. Use the ⇧⇩⇦⇨ keys to make selections. Press ENTER to continue. Press EXIT to save or discard changes and return to Run Mode.

5. **Program the UNITS menu first because later menus will be based on the units selected.**

****NOTE: The meter will come from the factory preprogrammed for your application. ****

Output Menu


Run Mode
ENTER
Password
ENTER
Output Menu
Use keys to access menus
4-20 mA Output 1 More >
4-20 mA Output 2 More >
4-20 mA Output 3 More >
*see below
< Measure >
None
Mass
Volume
*** Energy
Temp 1,2
Press
Density
• Total
< 4 mA = xxxx >
xxxx
< 20mA = xxxx >
xxxx
< Time Const (Sec)
xxxx
Scaled Frequency More >
< Max. Frequency >
xxxxx
*****
**see below
Modbus Units (Internal/Display)
Modbus Order
0-1:2-3
3-2:1-0
2-3:0-1
1-0:3-2
Comm Protocol Modbus RTU (None1, None2, Odd, Even)
Baud Rate
19200
Address
1
****see below
BACnet Device ID
xxx
BACnet MaxMaster
xxx
< 0 Hz = (units) >
xxxx
< Max Hz = (units) >
xxxx
* - Physical Layer not available on Two Wire Mass – Accessible via HART
** - Modbus not available on Two Wire Mass
*** - Energy available on EMS meters only
**** - BACnet meters only
***** - 10000 Hz maximum
• - Not available with standard HART

Example for Setting an Output

The following shows how to set Output 1 to measure mass flow with 4 mA = 0 lb/hr and 20 mA = 100 lb/hr with a time constant of 5 seconds. (All outputs are disabled while using the Setup Menus.)

First, set the desired units of measurement:

1. Use ⇦⇨ keys to move to the Units Menu (see page 0-44).
2. Press ⇩ key until Mass Flow Unit appears. Press ENTER.
3. Press ⇩ key until lb appears in the numerator. Press ⇨ key to move the underline cursor to the denominator. Press the ⇩ key until hr appears in the denominator. Press ENTER to select.
4. Press ⇧ key until Units Menu appears.

Second, set the analog output:

1. Use ⇦⇨ keys to move to the Output Menu.
2. Press the ⇩ key until 4-20 mA Output 1 appears.
3. Press ⇨ key to access Measure selections. Press ENTER and press the ⇩ key to select Mass. Press ENTER.
4. Press ⇨ key to set the 4 mA point in the units you have selected for mass of lb/hr. Press ENTER and use ⇧⇩⇦⇨ keys to set 0 or 0.0. Press ENTER.
5. Press ⇨ key to set the 20 mA point. Press ENTER and use ⇧⇩⇦⇨ keys to set 100 or 100.0. Press ENTER.
6. Press ⇨ key to select the Time Constant. Press ENTER and use ⇧⇩⇦⇨ keys to select 5. Press ENTER.
7. Press the EXIT key and answer YES to permanently save your changes.

Example for Calculating Output Current

Assumer Output 1 is scaled as above for mass flow with 4 mA = 0 lb/hr and 20 mA = 100 lb/hr.

Output 1 current = ((Flow rate / 100) x 16 mA) + 4 mA

Example for Setting a Scaled Frequency

The following shows how to set Scaled Frequency to measure temperature with Max. Frequency = 5000 Hz, 0 Hz = 0 °F, and MaxHz = 300°F with a time constant of 5 seconds. (All outputs are disabled while using the Setup Menus.)

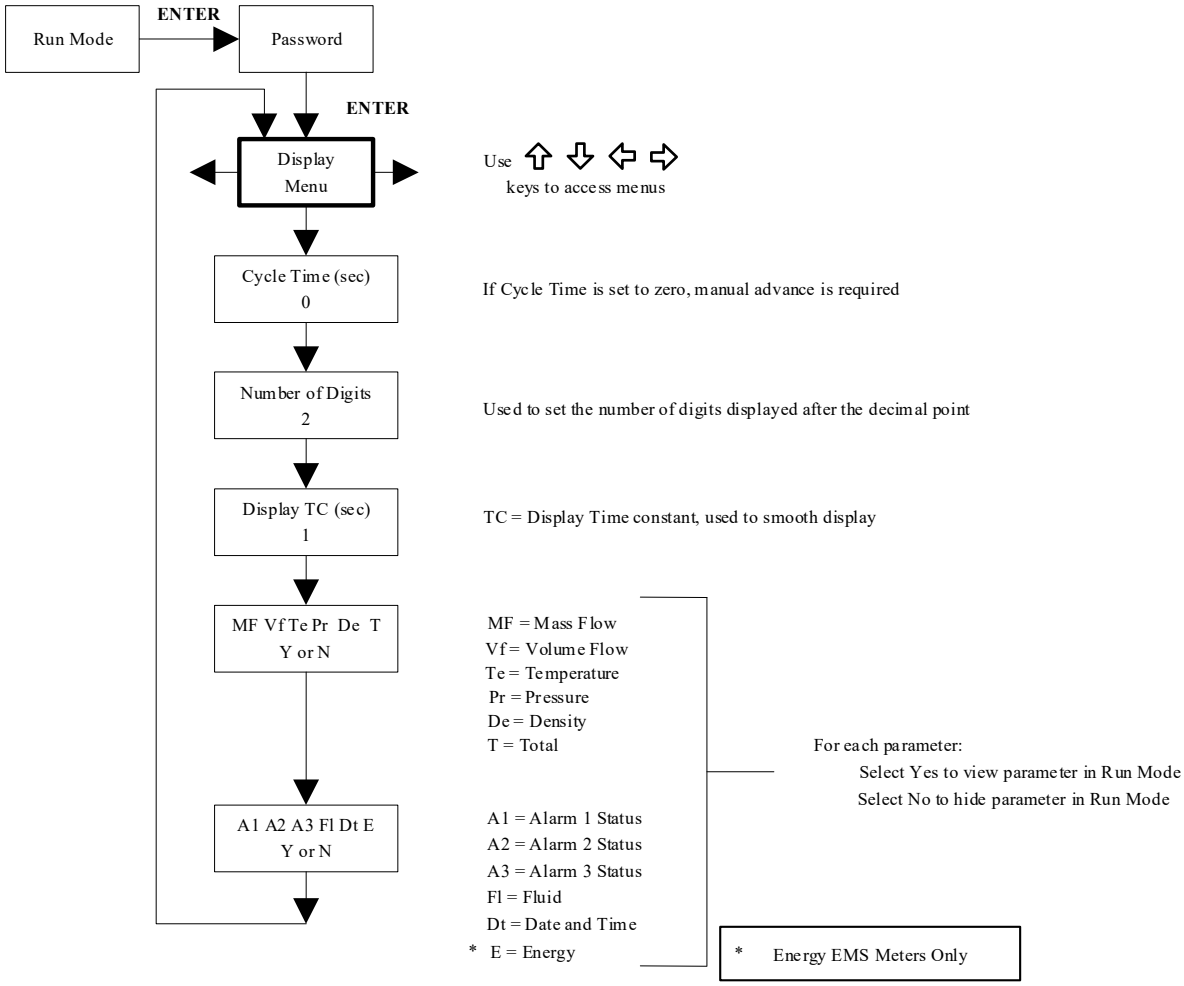
First, set the desired units of measurement:

5. Use ⇦⇨ keys to move to the Units Menu (see page 47).
6. Press ⇩ key until Mass Flow Unit appears. Press ENTER.
7. Press ⇩ key until lb appears in the numerator. Press ⇨ key to move the underline cursor to the denominator. Press the ⇩ key until hr appears in the denominator. Press ENTER to select.
8. Press ⇧ key until Units Menu appears.

Second, set the frequency output:

8. Use ⇦⇨ keys to move to the Output Menu.
9. Press the ⇩ key until Scaled Frequency appears.
10. Press ⇨ key to access Maximum Frequency selections. Press ENTER and use the ⇧⇩⇦⇨ keys to select frequency. Press ENTER.
11. Press ⇨ key to access Measure selections. Press ENTER and press the ⇩ key to select Temp. Press ENTER.
12. Press ⇨ key to set the 0 Hz point in the units you have selected for temperature of °F. Press ENTER and use ⇧⇩⇦⇨ keys to set 0 or 0.0. Press ENTER.
13. Press ⇨ key to set the Max. Hz point. Press ENTER and use ⇧⇩⇦⇨ keys to set 300 or 300.0. Press ENTER.
14. Press ⇨ key to select the Time Constant. Press ENTER and use ⇧⇩⇦⇨ keys to select 5. Press ENTER.
15. Press the EXIT key and answer YES to permanently save your changes.

Display Menu



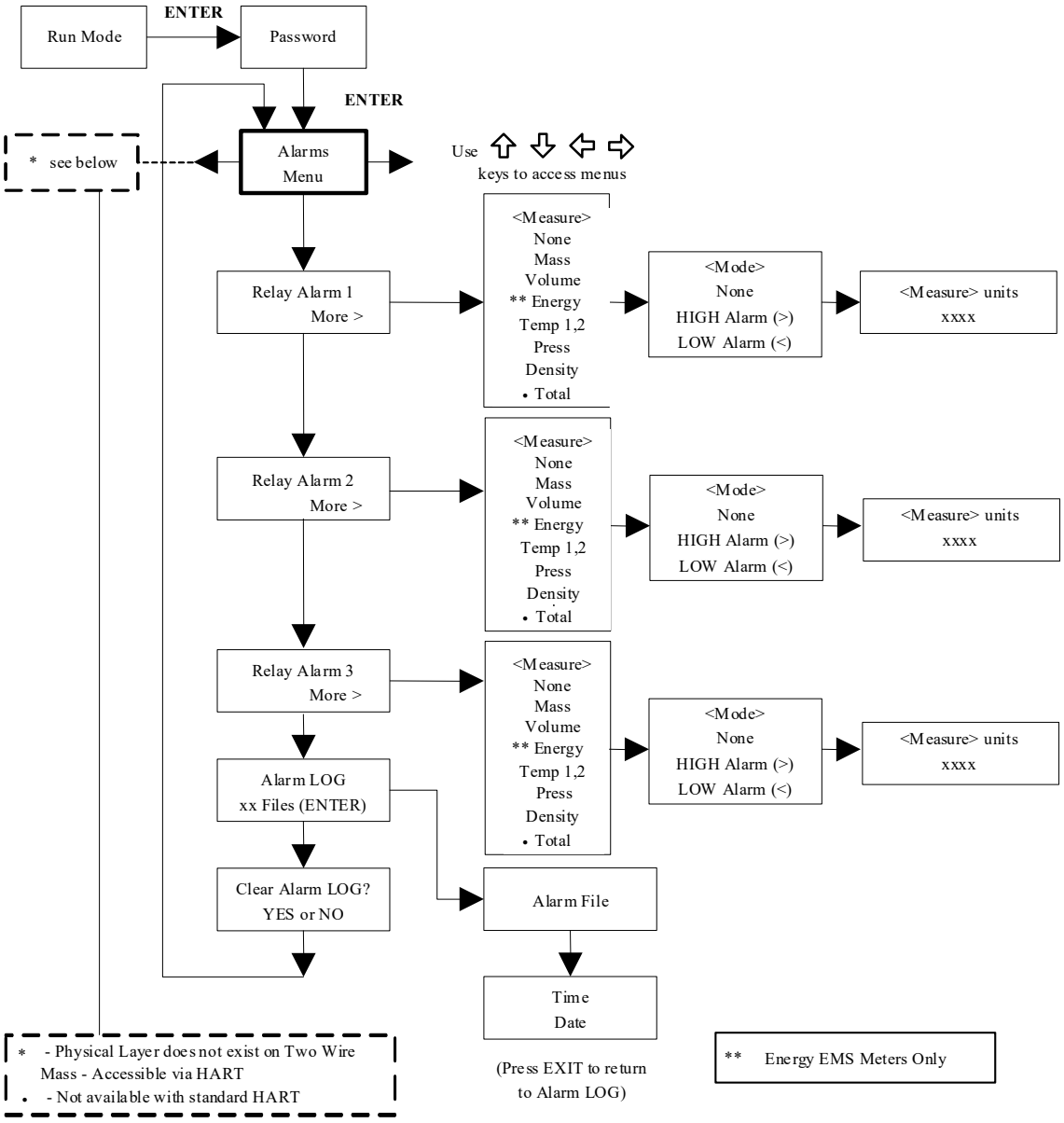
Use the Display Menu to set the cycle time for automatic screen sequencing used in the Run Mode, change the precision of displayed values, smooth the values or enable or disable each item displayed in the Run Mode screens.

Example for Changing a Run Mode Display Item

The following shows how to remove the temperature screen from the Run Mode screens. Note: all outputs are disabled while using the Setup Menus.

1. Use ⇦⇨ keys to move to the Display Menu.
2. Press ⇩ key until Mf Vf Pr Te De T appears.
3. Press ENTER to select. Press ⇨ key until the cursor is positioned below Te.
4. Press ⇩ key until N appears. Press ENTER to select.
5. Press EXIT and then ENTER to save changes and return to the Run Mode.

Alarms Menu


Run Mode
ENTER
Password
ENTER
* see below
Alarms Menu
Use keys to access menus
Relay Alarm 1 More >
Relay Alarm 2 More >
Relay Alarm 3 More >
Alarm LOG xx Files (ENTER)
Clear Alarm LOG? YES or NO
<Measure> None Mass Volume ** Energy Temp 1,2 Press Density • Total
<Mode> None HIGH Alarm (>) LOW Alarm (<)
<Measure> units xxxx
Alarm File
Time Date
(Press EXIT to return to Alarm LOG)
* - Physical Layer does not exist on Two Wire Mass - Accessible via HART
• - Not available with standard HART
** Energy EMS Meters Only

Example for Setting an Alarm

The following shows how to set Relay Alarm 1 to activate if the mass flow rate is greater than 100 lb/hr. You can check the alarm configuration in the Run Mode by pressing the ⇧⇩ keys until Alarm [1] appears. The lower line displays the mass flow rate at which the alarm activates. Note: all outputs are disabled while using the Setup Menus.

First, set the desired units of measurement:

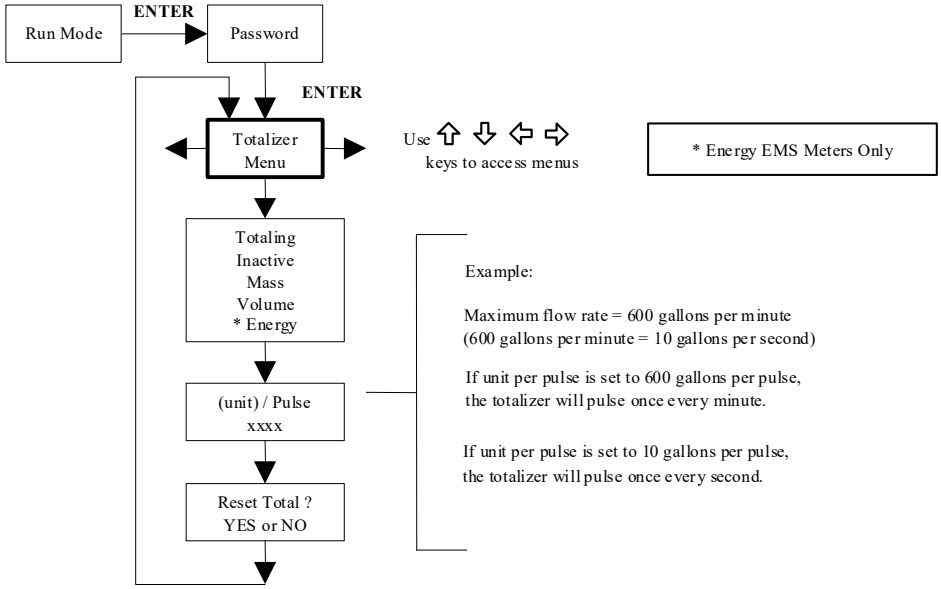
1. Use ⇦⇨ keys to move to the Units Menu (see to page 47).
2. Press ⇩ key until Mass Flow Unit appears. Press ENTER.
3. Press ⇩ key until lb appears in the numerator. Press ⇨ key to move the underline cursor to the denominator. Press the ⇩ key until hr appears in the denominator. Press ENTER to select.
4. Press ⇧ key until Units Menu appears.

Second, set the alarm:

1. Use ⇦⇨ keys to move to the Alarms Menu.
2. Press the ⇩ key until Relay Alarm 1 appears.
3. Press ⇨ key to access Measure selections. Press ENTER and use the ⇩ key to select Mass. Press ENTER.
4. Press ⇨ key to select the alarm Mode. Press ENTER and use ⇩ key to select HIGH Alarm. Press ENTER.
5. Press ⇨ key to select the value that must be exceeded before the alarm activates. Press ENTER and use ⇧⇩⇦⇨ keys to set 100 or 100.0. Press ENTER.
6. Press the EXIT key to save your changes. (Alarm changes are always permanently saved.)

(Up to three relay alarm outputs are available depending on meter configuration.)

Totalizer #1 Menu



Use the Totalizer Menu to configure and monitor the totalizer. The totalizer maximum count is 999,999,999 at which point it will roll over to 0. The totalizer output is a 50 millisecond (.05 second) positive pulse (relay closed for 50 milliseconds). The totalizer cannot operate faster than one pulse every 100 millisecond (.1 second). A good rule to follow is to set the unit per pulse value equal to the maximum flow in the same units per second. This will limit the pulse to no faster than one pulse every second.

Example for Setting the Totalizer

The following shows how to set the totalizer to track mass flow in kg/sec (All outputs are disabled while using the Setup Menus).

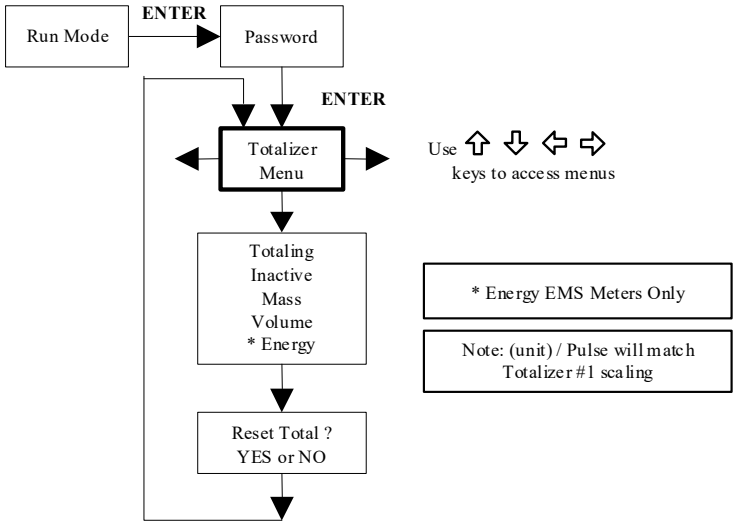
First, set the desired units of measurement:

1. Use ⇦⇨ keys to move to the Units Menu (see to page 47).
2. Press ⇩ key until Mass Flow Unit appears. Press ENTER.
3. Press ⇩ key until kg appears in the numerator. Press ⇨ key to move the underline cursor to the denominator. Press the ⇩ key until sec appears in the denominator. Press ENTER to select.
4. Press ⇧ key until Units Menu appears.

Second, set the pulse output:

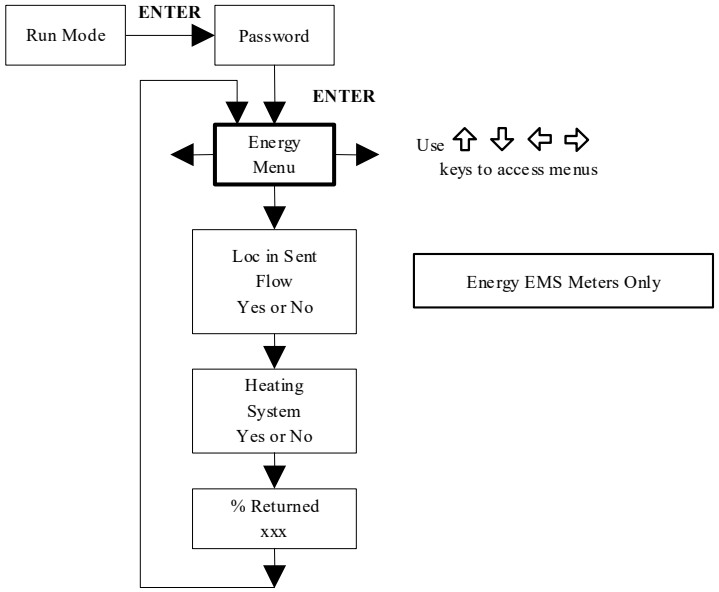
1. Use ⇦⇨ keys to move to the Totalizer Menu.
2. Press the ⇩ key until Totaling appears.
3. Press ENTER and press the ⇩ key to select Mass. Press ENTER.
4. Press ⇩ key to set the pulse output in the units you have selected for mass flow of kg/sec. Press ENTER and use ⇧⇩⇦⇨ keys to set the pulse value equal to the maximum flow in the same units per second. Press ENTER.
5. To reset the totalizer, press ⇩ key until Reset Total? appears. Press ENTER and the ⇩ key to reset the totalizer if desired. Press ENTER.
6. Press the EXIT key and answer YES to permanently save your changes.

Totalizer #2 Menu



Use the Totalizer #2 to Monitor Flow or Energy. The totalizer maximum count is 999,999,999 at which point it will roll over to 0. Note that Totalizer #2 does not operate a relay, it is for monitoring only.

Energy Menu (For EMS Energy Meters Only)



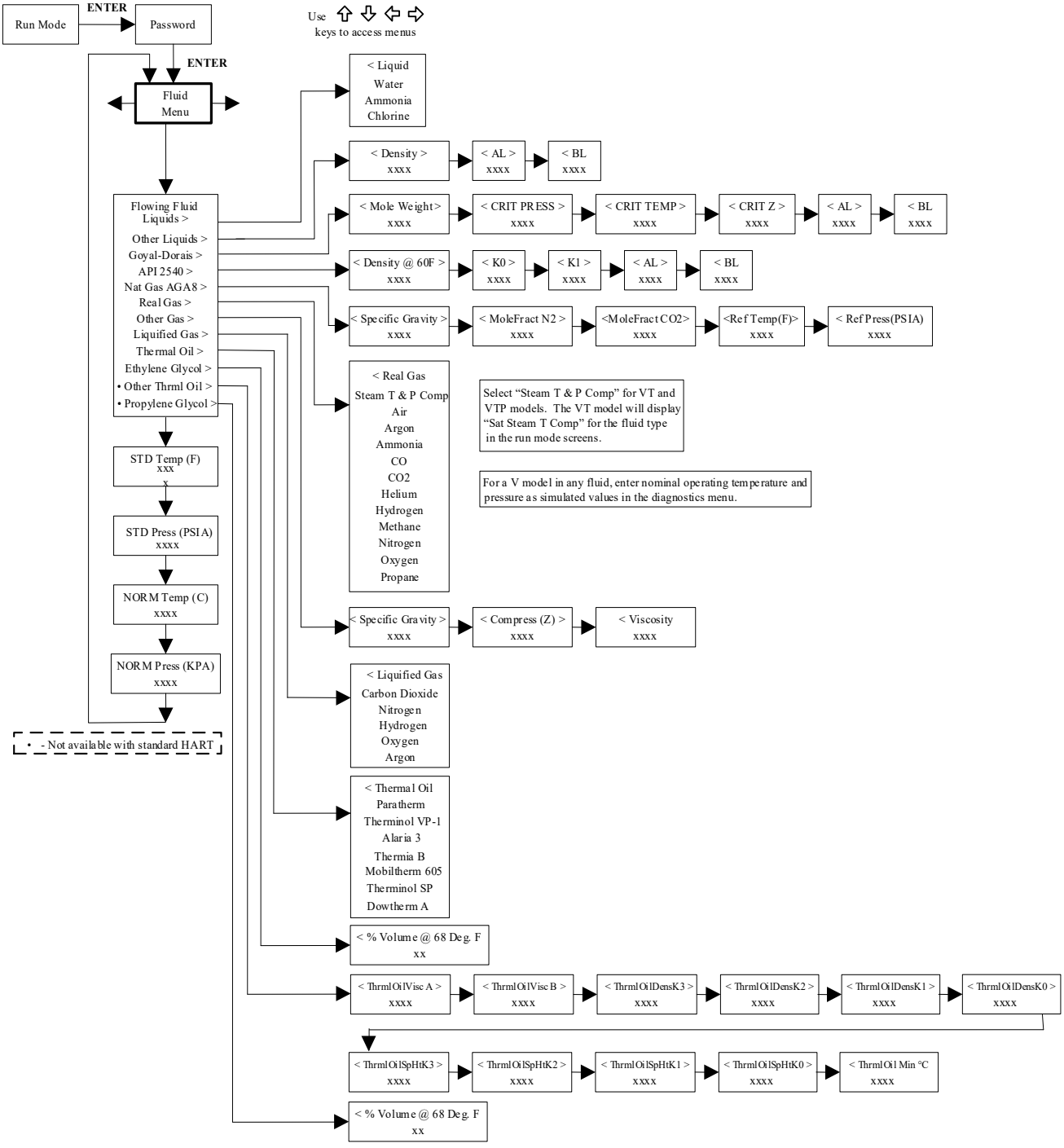
Configuration:
There are several possibilities regarding the measurement of water or steam energy given the location of the meter and the use of a second RTD. The table below summarizes the possibilities:

Fluid	Meter Location	Second RTD	Measurement
Water	"Sent" Flow Line	"Return" Flow Line	Change in Energy
Water	"Return" Flow Line	"Sent" Flow Line	Change in Energy
Water	"Sent" Flow Line	None	Outgoing Energy
Steam	"Sent" Flow Line	"Return" Flow Line (condensate)	Change in Energy
Steam	"Sent" Flow Line	None	Outgoing Energy

As above, you must properly configure the meter in the Energy Menu.

1. Loc in Sent Flow? Select Yes or No based on where the meter is located. Refer to the above table
2. Heating System? Select Yes for a hot water system used for heating. Select No for a chilled water system used for cooling. Always select Yes for a steam system.
3. % Returned. Select a number between 0% and 100%. Estimate the amount of water that returns. It is usually 100%, or can be less than 100% if historical data shows the amount of makeup water used. If a second RTD is not used, set to 0%. When 0% is selected, the energy calculation represents the outgoing energy only (no return energy is subtracted). **NOTE: the meter ships from the factory assuming 0% return and has a 1000 ohm resistor installed in the RTD #2 wiring location. This needs to be removed if the meter is to be used in a manner other than with 0% return and with the customer supplied RTD in its place.**

Fluid Menu


Run Mode
ENTER
Password
ENTER
Fluid Menu
Use ⇧ ⇩ ⇦ ⇨ keys to access menus
Flowing Fluid Liquids >
Other Liquids >
Goyal-Dorais >
API 2540 >
Nat Gas AGA8 >
Real Gas >
Other Gas >
Liquified Gas >
Thermal Oil >
Ethylene Glycol >
• Other Thrml Oil >
• Propylene Glycol >
STD Temp (F) xxx x
STD Press (PSIA) xxxx
NORM Temp (C) xxxx
NORM Press (KPA) xxxx
• - Not available with standard HART
< Liquid
Water
Ammonia
Chlorine
< Density > xxxx
< AL > xxxx
< BL xxxx
< Mole Weight> xxxx
< CRIT PRESS > xxxx
< CRIT TEMP > xxxx
< CRIT Z > xxxx
< AL > xxxx
< BL xxxx
< Density @ 60F > xxxx
< K0 > xxxx
< K1 > xxxx
< AL > xxxx
< BL xxxx
< Specific Gravity > xxxx
< MoleFract N2 > xxxx
<MoleFract CO2> xxxx
<Ref Temp(F)> xxxx
< Ref Press(PSIA) xxxx
< Real Gas
Steam T & P Comp
Air
Argon
Ammonia
CO
CO2
Helium
Hydrogen
Methane
Nitrogen
Oxygen
Propane
Select “Steam T & P Comp” for VT and VTP models. The VT model will display “Sat Steam T Comp” for the fluid type in the run mode screens.
For a V model in any fluid, enter nominal operating temperature and pressure as simulated values in the diagnostics menu.
< Specific Gravity > xxxx
< Compress (Z) > xxxx
< Viscosity xxxx
< Liquified Gas
Carbon Dioxide
Nitrogen
Hydrogen
Oxygen
Argon
< Thermal Oil
Paratherm
Therminol VP-1
Alaria 3
Thermia B
Mobiltherm 605
Therminol SP
Dowtherm A
< % Volume @ 68 Deg. F xx
< ThrmlOilVisc A > xxxx
< ThrmlOilVisc B > xxxx
< ThrmlOilDensK3 > xxxx
< ThrmlOilDensK2 > xxxx
< ThrmlOilDensK1 > xxxx
< ThrmlOilDensK0 > xxxx
< ThrmlOilSpHtK3 > xxxx
< ThrmlOilSpHtK2 > xxxx
< ThrmlOilSpHtK1 > xxxx
< ThrmlOilSpHtK0 > xxxx
< ThrmlOil Min °C xxxx
< % Volume @ 68 Deg. F xx

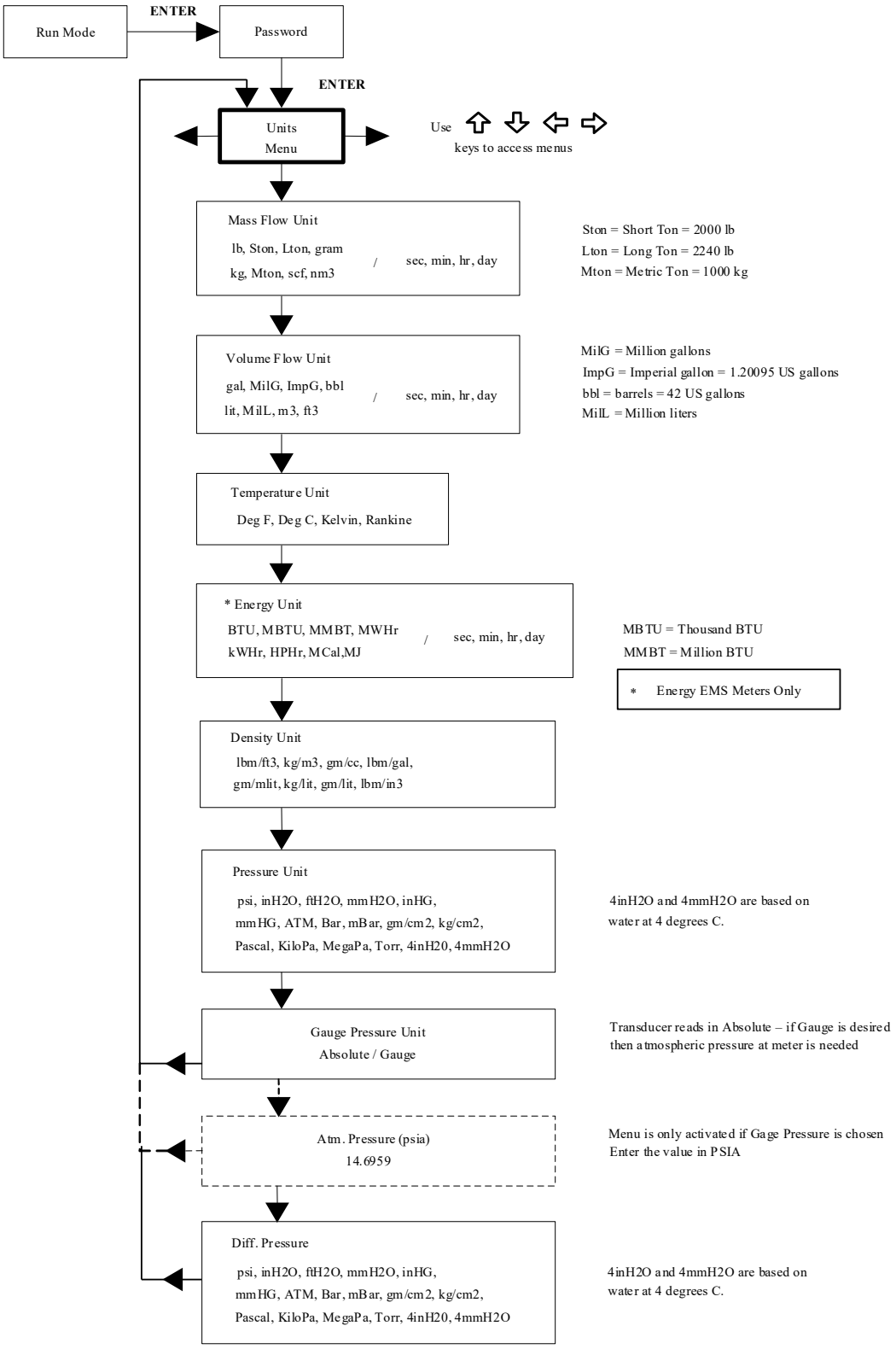
Use the Fluid Menu to configure the flow meter for use with common gases, liquids and steam. Your flow meter is pre-programmed at the factory for your application's process fluid.

Reference Richard W. Miller, *Flow Measurement Engineering Handbook (Third Edition, 1996),* page 2-75 for definition and use of the Goyal-Doraiswamy equation and page 2-76 for the definition and use of the API 2540 equation. Also, see Appendix C for Fluid Calculation equations.

The units of measurement used in the Fluid Menu are preset and are as follows:

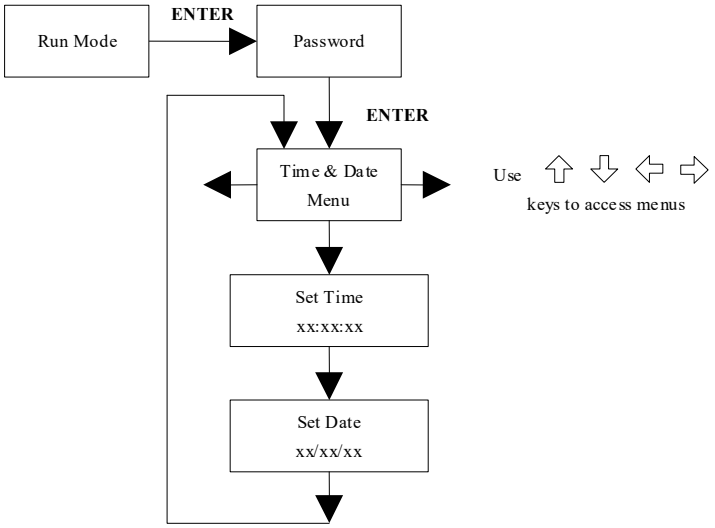
Mole Weight = $lb_m/(lb_m \cdot mol)$, CRIT PRESS = psia, CRIT TEMP = °R, Density = lbm/ft^3 and Viscosity = cP (centipoise).

Units Menu


Run Mode
ENTER
Password
ENTER
Units Menu
Use keys to access menus
Mass Flow Unit
lb, Ston, Lton, gram
kg, Mton, scf, nm3
/ sec, min, hr, day
Ston = Short Ton = 2000 lb
Lton = Long Ton = 2240 lb
Mton = Metric Ton = 1000 kg
Volume Flow Unit
gal, MilG, ImpG, bbl
lit, MilL, m3, ft3
/ sec, min, hr, day
MilG = Million gallons
ImpG = Imperial gallon = 1.20095 US gallons
bbl = barrels = 42 US gallons
MilL = Million liters
Temperature Unit
Deg F, Deg C, Kelvin, Rankine
* Energy Unit
BTU, MBTU, MMBT, MWHr
kWHr, HPHr, MCal,MJ
/ sec, min, hr, day
MBTU = Thousand BTU
MMBT = Million BTU
* Energy EMS Meters Only
Density Unit
lbm/ft3, kg/m3, gm/cc, lbm/gal,
gm/mlit, kg/lit, gm/lit, lbm/in3
Pressure Unit
psi, inH2O, ftH2O, mmH2O, inHG,
mmHG, ATM, Bar, mBar, gm/cm2, kg/cm2,
Pascal, KiloPa, MegaPa, Torr, 4inH20, 4mmH2O
4inH2O and 4mmH2O are based on water at 4 degrees C.
Gauge Pressure Unit
Absolute / Gauge
Transducer reads in Absolute – if Gauge is desired then atmospheric pressure at meter is needed
Atm. Pressure (psia)
14.6959
Menu is only activated if Gage Pressure is chosen
Enter the value in PSIA
Diff. Pressure
psi, inH2O, ftH2O, mmH2O, inHG,
mmHG, ATM, Bar, mBar, gm/cm2, kg/cm2,
Pascal, KiloPa, MegaPa, Torr, 4inH20, 4mmH2O
4inH2O and 4mmH2O are based on water at 4 degrees C.

Use the Units Menu to configure the flow meter with the desired units of measurement. (These are global settings and determine what appears on all screens.

Time & Date Menu



Use the Time and Date Menu to enter the correct time and date into the flow meter's memory. The parameters are used in the Run Mode and the alarm and system log files.

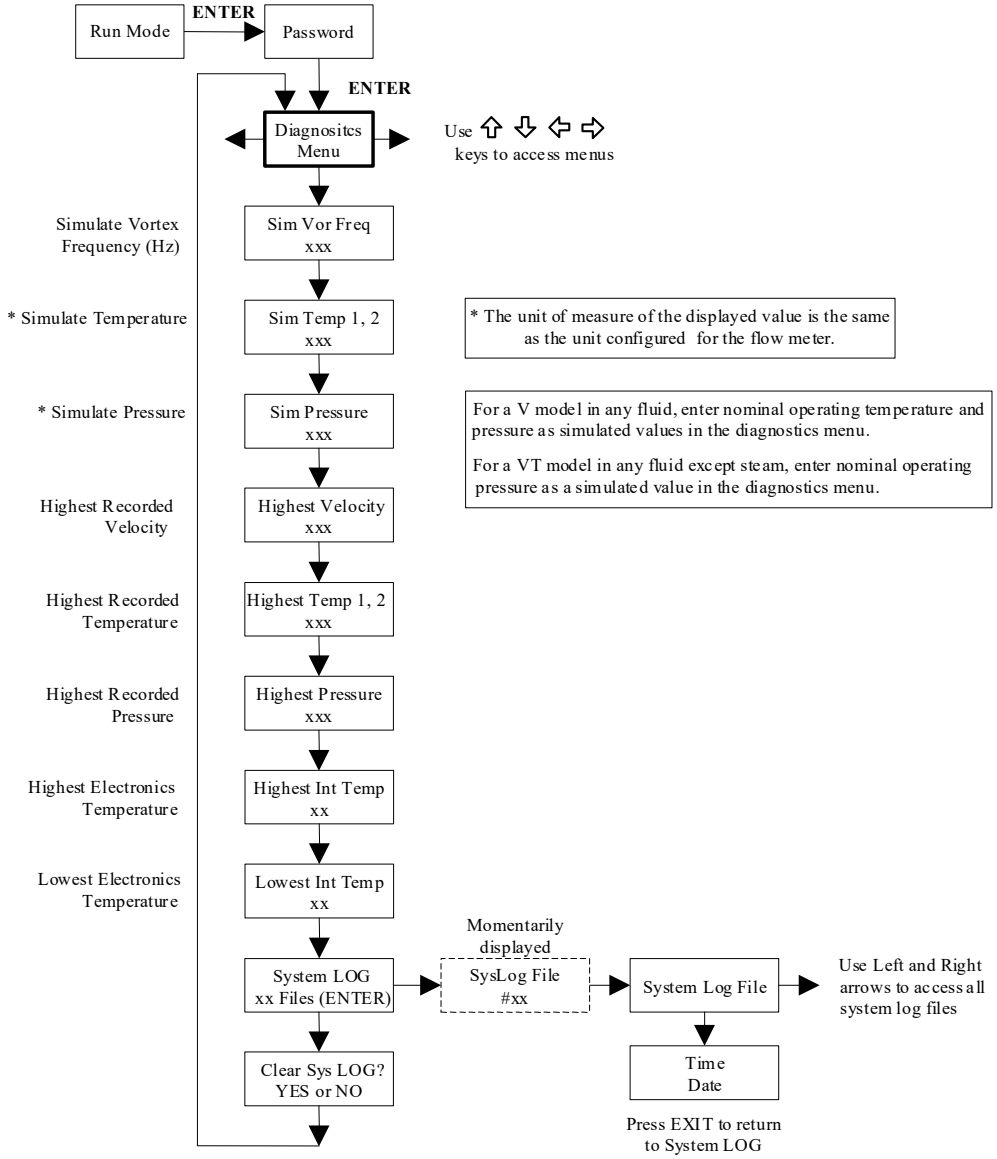
Note: Time is displayed in AM/PM format, but military format is used to set the time. For example, 1:00 PM is entered as 13:00:00 in the Set Time menu.

Example for Setting the Time

How to set the time to 12:00:00. You can check the time in the Run Mode by pressing the ⇧⇩ keys until the Time & Date screen appears. Note: all outputs are disabled while using the Setup Menus.

1. Use ⇦⇨ keys to move to the Time and Date Menu.
2. Press ⇩ key until Set Time appears. Press ENTER.
3. Press ⇩ key until 1 appears. Press ⇨ key to move the underline cursor to the next digit. Press the ⇩ key until 2 appears. Continue sequence until all desired parameters are entered. Press ENTER to return to the Time and Date Menu.
4. Press EXIT to return to the Run Mode.

Diagnostics Menu

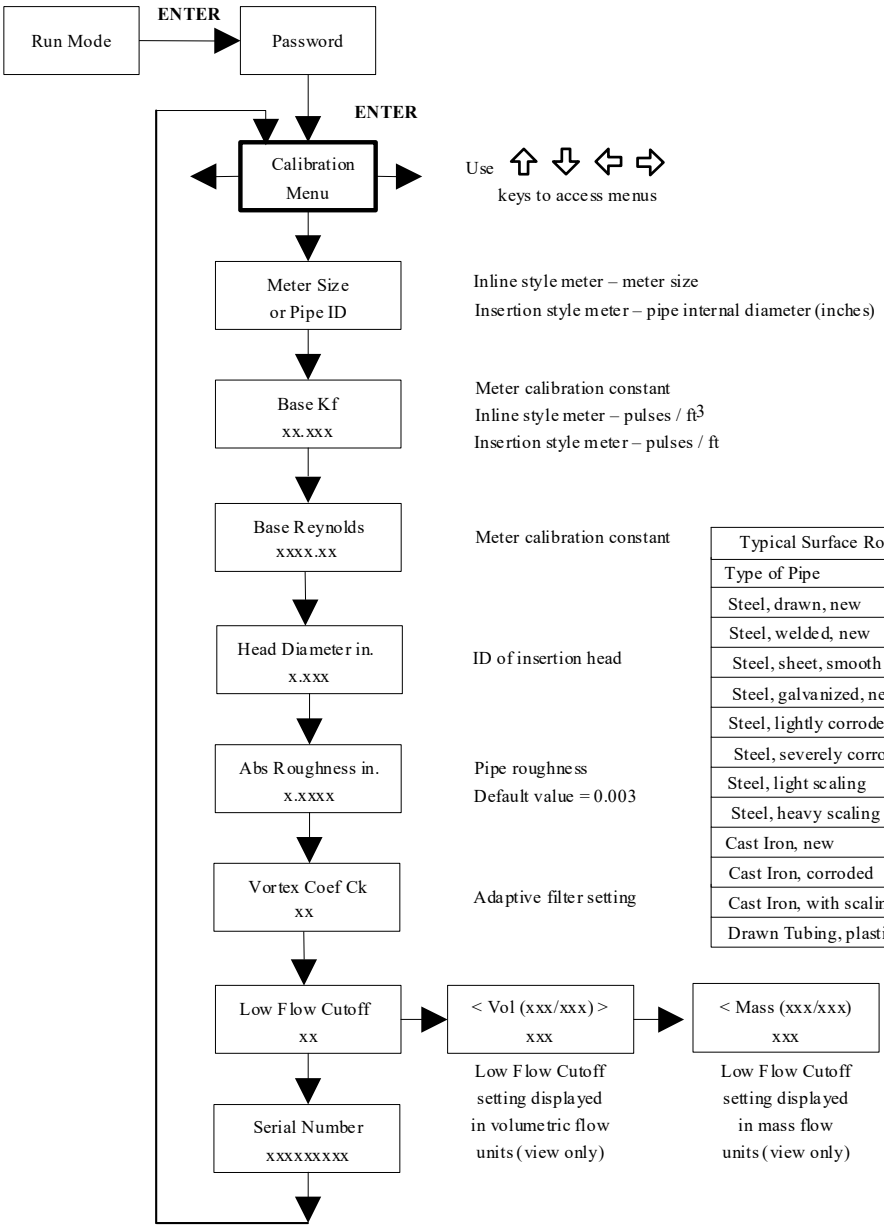


Use the Diagnostics Menu to simulate operation and review the system files. The system log files contain time/date stamped messages including: power on, power off, programming time outs, parameter faults, incorrect password entry and other various information relative to system operation and programming.

The simulated inputs are for testing the meter to verify that the programming is correct. They are also used to enter nominal operating temperature and pressure for the V only model. Simulated vortex frequency allows you to enter any value for the sensor input in Hz. The meter will calculate a flow rate based on the corresponding value and update all analog outputs **(the totalizer display and output is not affected by a simulated frequency)**. The simulated pressure and temperature settings work the same way. The meter will output these new values and will use them to calculate a new density for mass flow measurement. Note: when your diagnostic work is complete, make sure to return the values to zero to allow the electronics to use the actual transducer values. For the V only model keep the temperature and pressure at nominal operating conditions.

If the meter display indicates a temperature or pressure fault, a substitute value can be entered to allow flow calculations to continue at a fixed value until the source of the fault is identified and corrected. The units of measure of the displayed values are the same as the units configured for the flow meter.

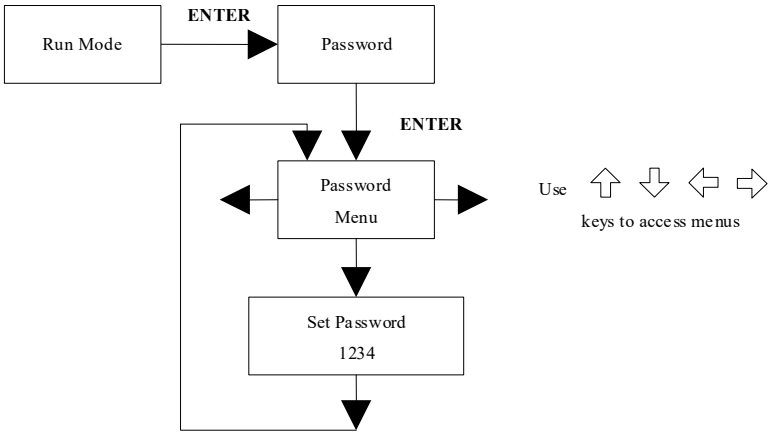
Calibration Menu



Typical Surface Roughness (inches)	
Type of Pipe	Roughness
Steel, drawn, new	0.0024
Steel, welded, new	0.003
Steel, sheet, smooth	0.0028
Steel, galvanized, new	0.006
Steel, lightly corroded	0.01
Steel, severely corroded	0.068
Steel, light scaling	0.05
Steel, heavy scaling	0.11
Cast Iron, new	0.025
Cast Iron, corroded	0.06
Cast Iron, with scaling	0.1
Drawn Tubing, plastic	0.00006

The Calibration Menu contains the calibration coefficients for the flow meter. These values should be changed only by properly trained personnel. The Vortex Coef Ck and Low Flow Cutoff are set at the factory. Consult the factory for help with these settings if the meter is showing erratic flow rate.

Password Menu



Use the Password Menu to set or change the system password. The factory-set password is 1234.

Chapter 4 Serial Communications

HART Communications

The HART Communications Protocol (Highway Addressable Remote Transducer Protocol) is a bidirectional digital serial communications protocol. The HART signal is based on the Bell 202 standard and is superimposed on 4-20 mA Output 1. Peer-to-peer (analog / digital) and multi-drop (digital only) modes are supported.

Wiring

The diagrams below detail the proper connections required for HART communications:

Warning!
Place controls in manual mode when making configuration changes to the vortex meter.

DC Powered Meter Wiring

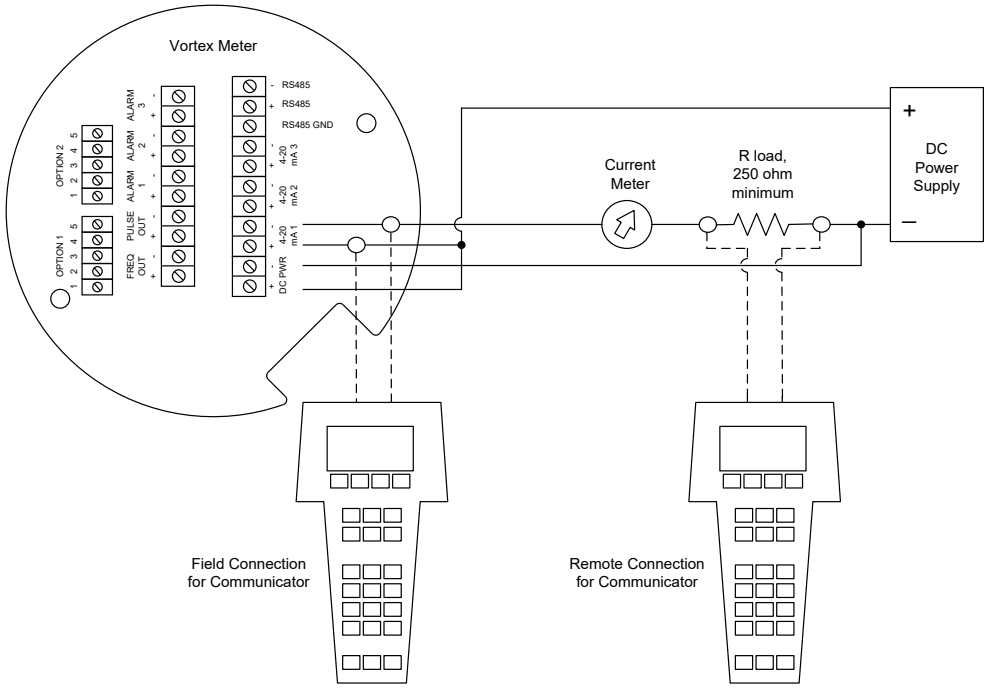


Figure 4.1 - DC Powered Meter Wiring (HART)

AC Powered Meter Wiring

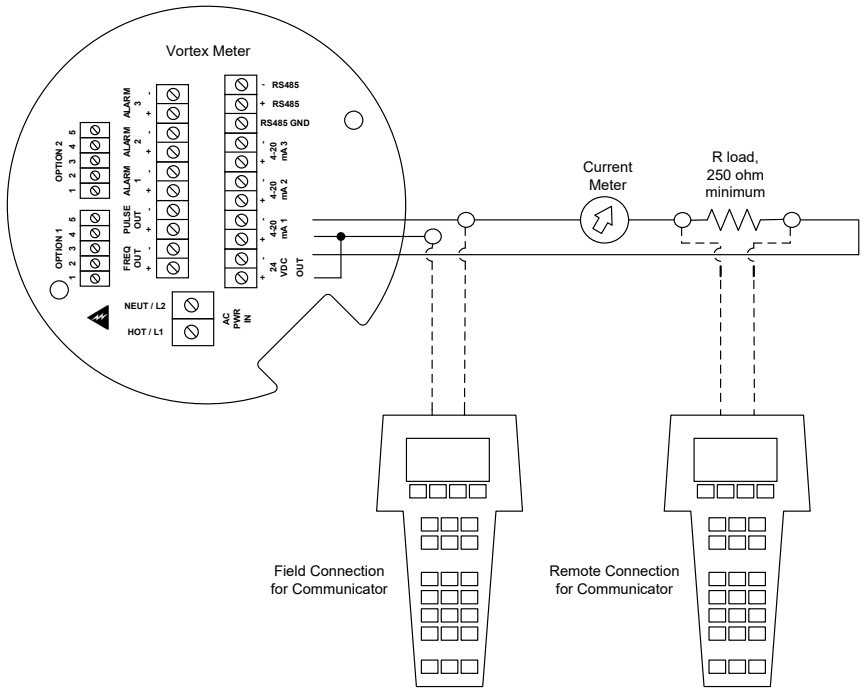
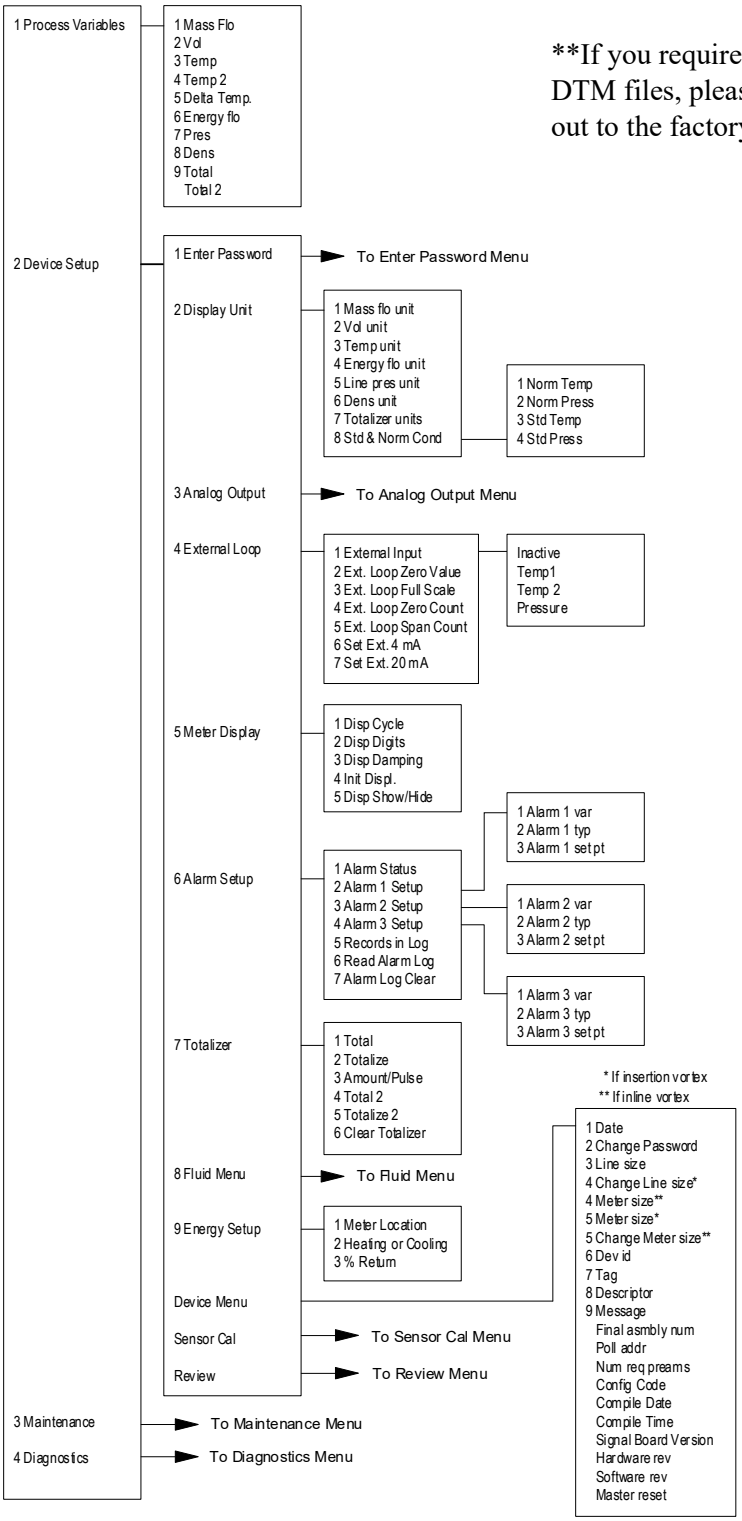


Figure 4.2 - AC Powered Meter Wiring (HART)

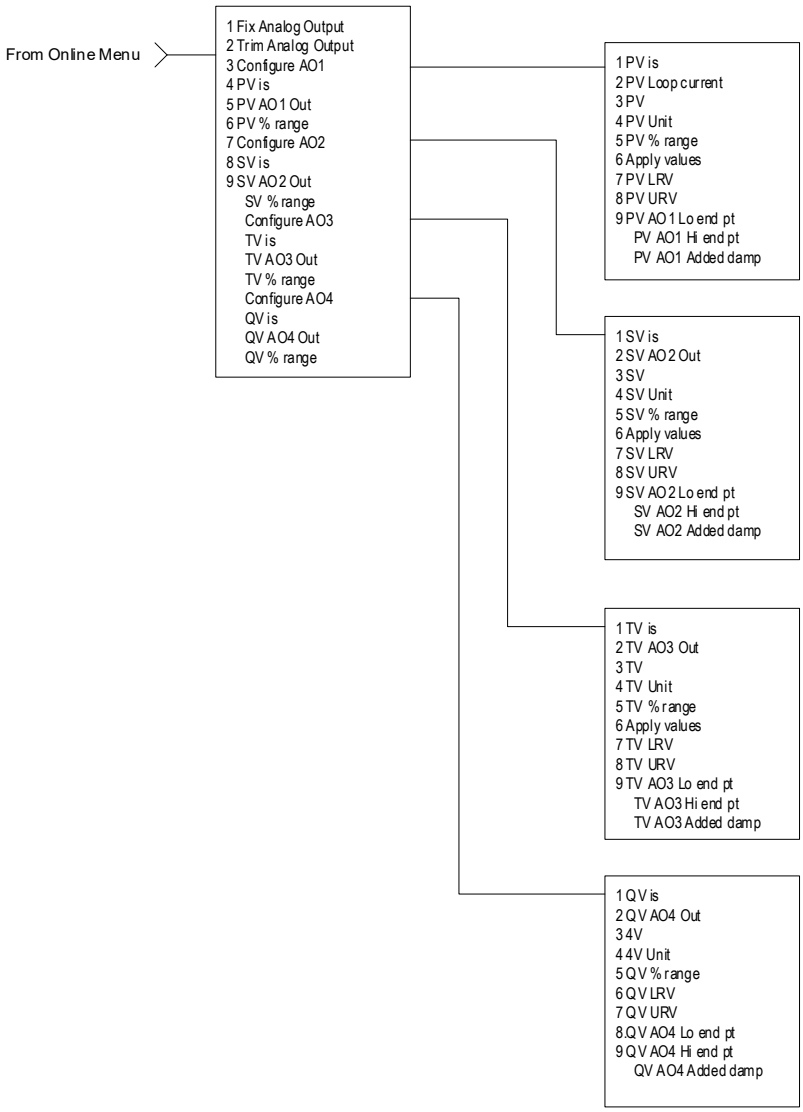
HART Commands with the DD Menu

Online Menu

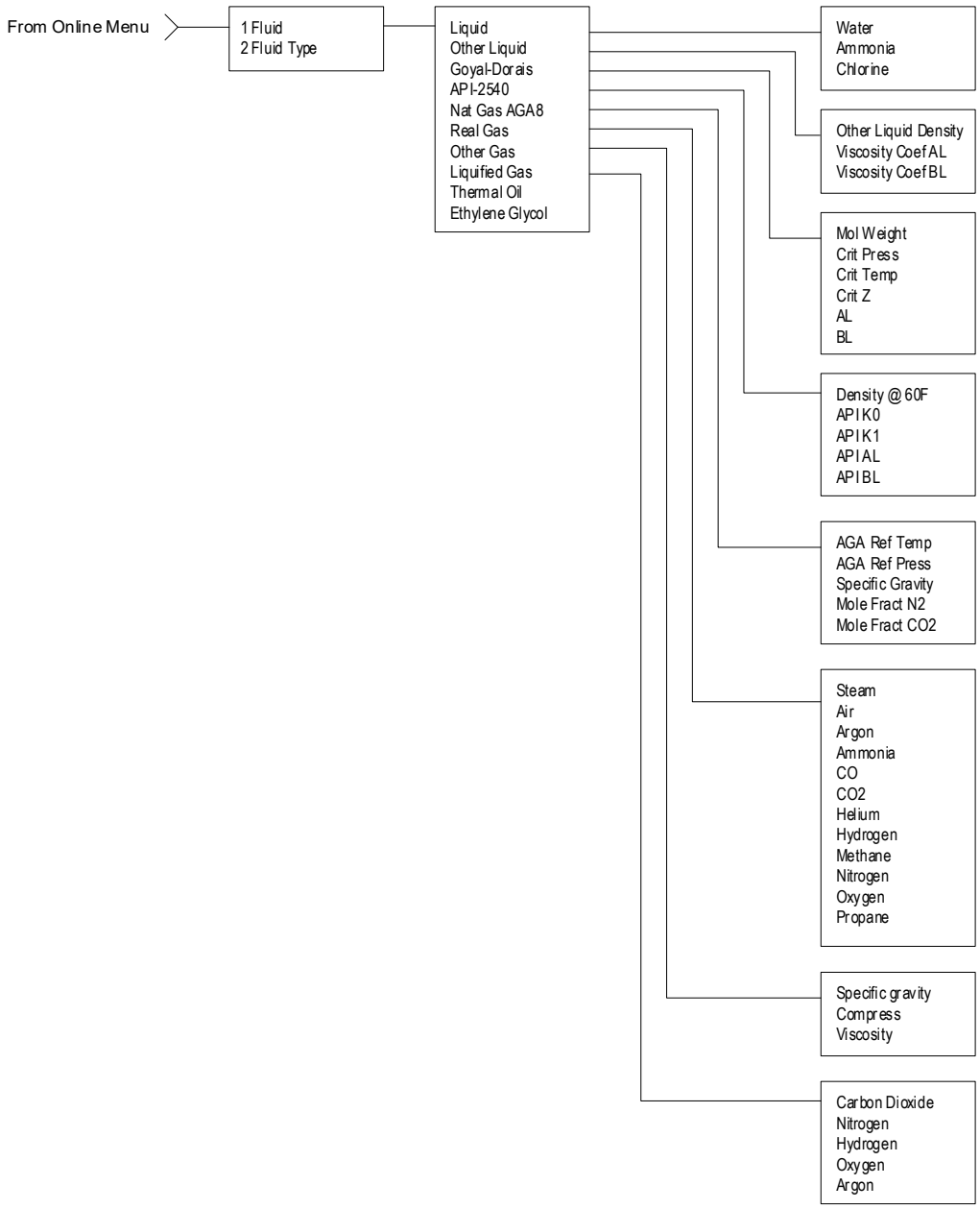


**If you require DD or DTM files, please reach out to the factory for a link.

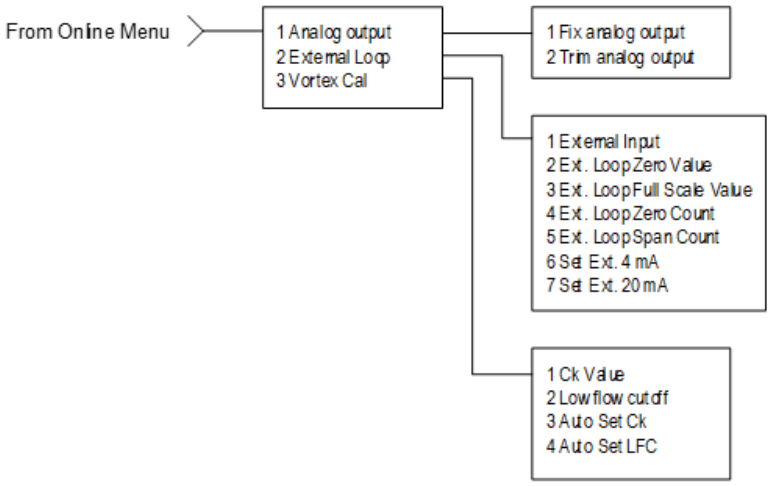
Analog Output Menu



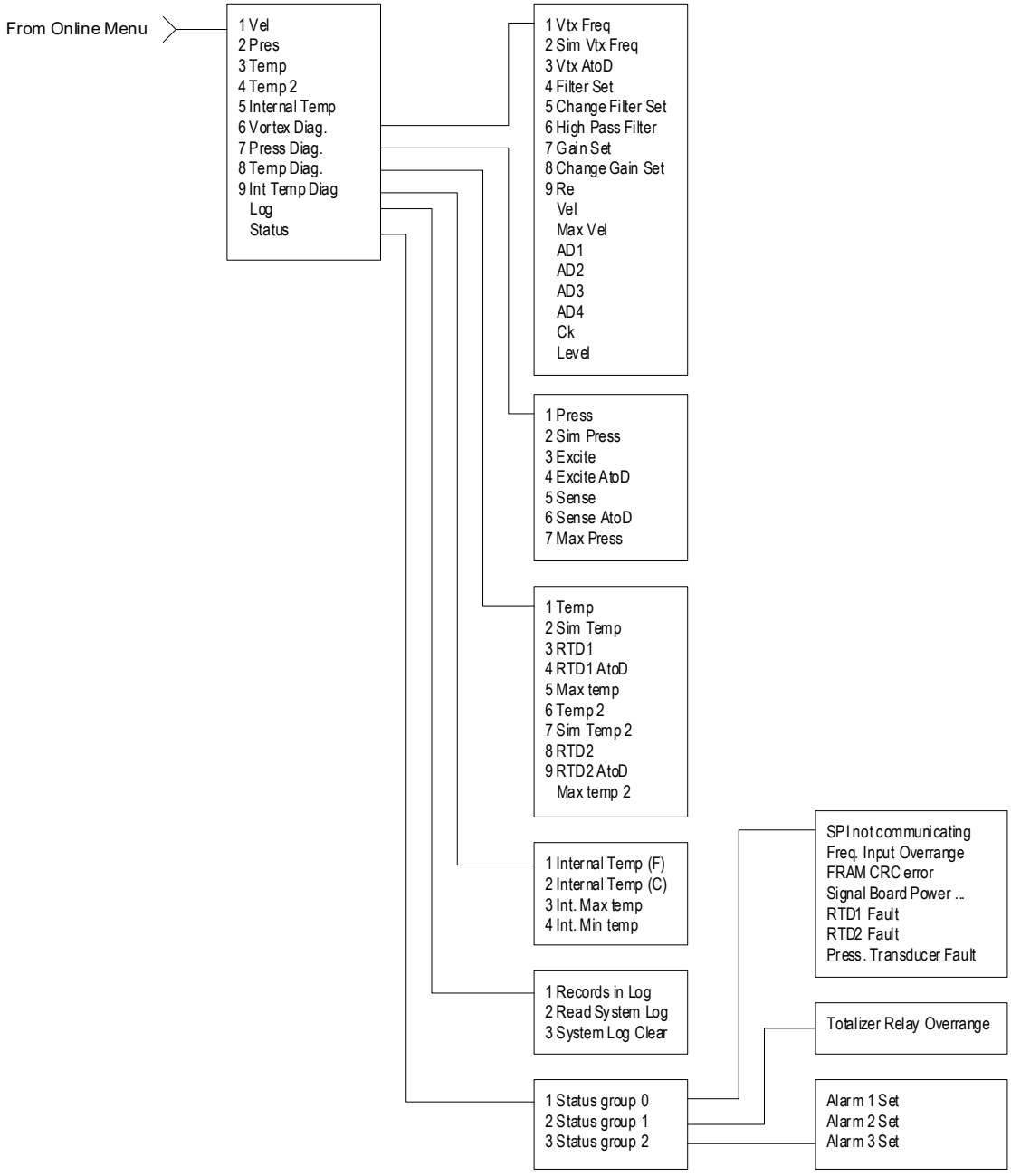
Fluid Menu


From Online Menu
1 Fluid
2 Fluid Type
Liquid
Other Liquid
Goyal-Dorais
API-2540
Nat Gas AGA8
Real Gas
Other Gas
Liquified Gas
Thermal Oil
Ethylene Glycol
Water
Ammonia
Chlorine
Other Liquid Density
Viscosity Coef AL
Viscosity Coef BL
Mol Weight
Crit Press
Crit Temp
Crit Z
AL
BL
Density @ 60F
API K0
API K1
API AL
API BL
AGA Ref Temp
AGA Ref Press
Specific Gravity
Mole Fract N2
Mole Fract CO2
Steam
Air
Argon
Ammonia
CO
CO2
Helium
Hydrogen
Methane
Nitrogen
Oxygen
Propane
Specific gravity
Compress
Viscosity
Carbon Dioxide
Nitrogen
Hydrogen
Oxygen
Argon

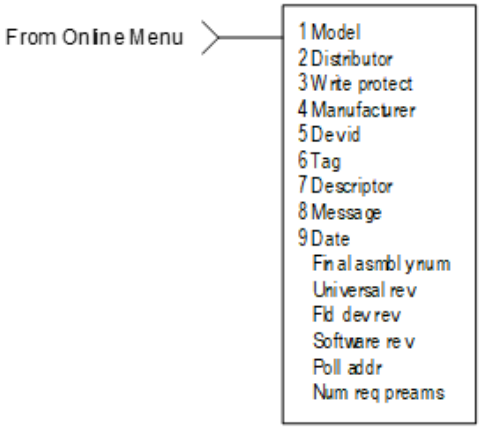
Maintenance Menu



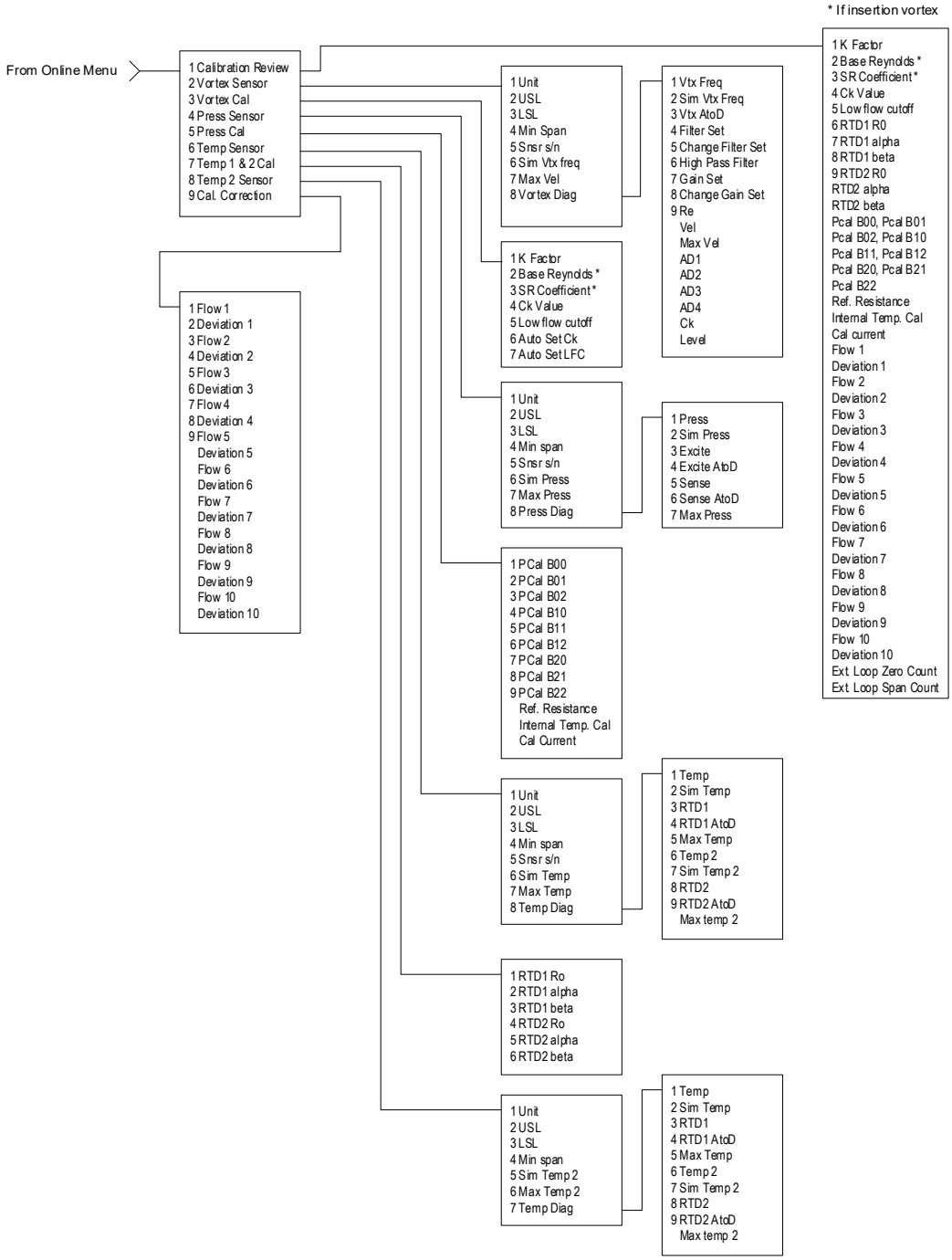
Diagnostics Menu



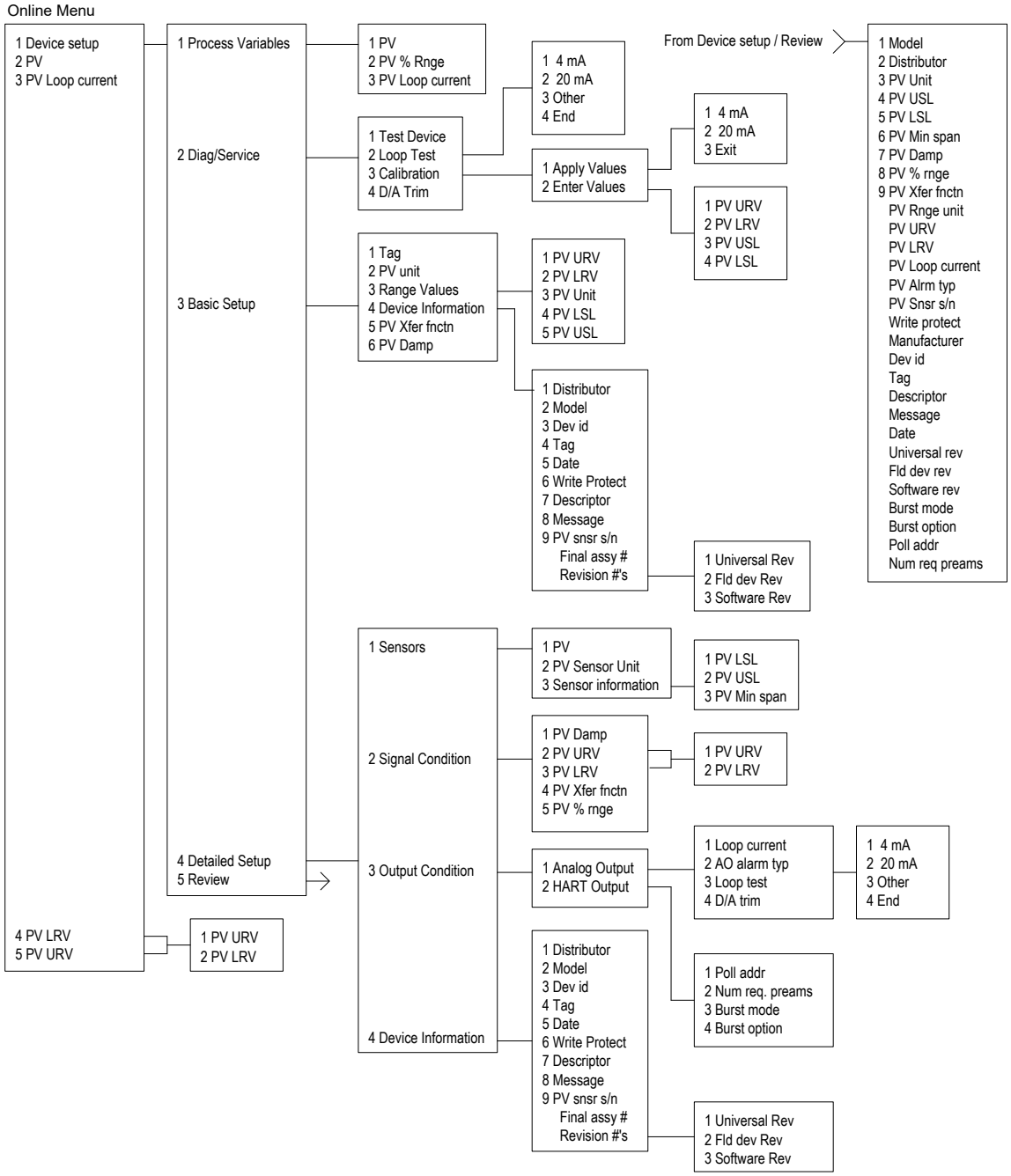
Review Menu


From Online Menu
1 Model
2 Distributor
3 Write protect
4 Manufacturer
5 Devid
6 Tag
7 Descriptor
8 Message
9 Date
Final asmbl ynum
Universal rev
Fld dev rev
Software rev
Poll addr
Num req preams

Sensor Cal Menu



HART Commands with Generic DD Menu



Modbus Communications

Warning!
Place controls in manual mode when making configuration changes to the vortex meter.

Applicable Flow Meter Models

VorTek FlowCalc™ Flow Computer with Modbus communication protocol and firmware version 4.00.58 and above.

Overview

This document describes the preliminary implementation of the Modbus communication protocol for use in monitoring common process variables in the VorTek FlowCalc™ Flow Computer. The physical layer utilizes the half-duplex RS-485 port, and the Modbus protocol.

Reference Documents

The following documents are available online from www.modbus.org.

Modbus Application Protocol Specification V1.1
Modbus Over Serial Line Specification & Implementation Guide V1.0
Modicon Modbus Protocol Reference Guide PI–MBUS–300 Rev. J

Wiring

An RS485 daisy chained network configuration as depicted below is recommended. Do not use a star, ring, or cluster arrangement.

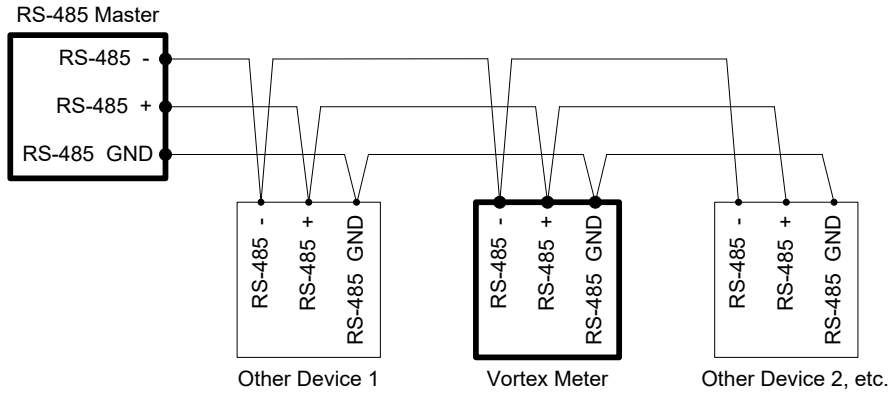


Figure 4.3 - RS-485 Wiring (MODBUS)

Pin Labeling Among Devices

"RS-485 –" = "A" = "TxD-/RxD-" = "Inverting pin"

"RS-485 +" = "B" = "TxD+/RxD+" = "Non-Inverting pin"

"RS-485 GND" = "GND" = "G" = "SC" = "Reference"

Menu Items

The following menu items are in the Output Menu and allow selection and control of the Modbus communication protocol.

Address

When the Modbus protocol is selected, the Modbus address is equal to the user programmable device address if it is in the range 1…247, in accordance with the Modbus specification. If the device address is zero or is greater than 247, then the Modbus address is internally set to 1.

Comm Protocol

The Comm Protocol menu allows selection of "Modbus RTU Even," "Modbus RTU Odd," "Modbus RTU None2," or "Modbus RTU None1," (non-standard Modbus) with Even, Odd and None referring to the parity selection. When even or odd parity is selected, the unit is configured for 8 data bits, 1 parity bit and 1 stop bit; with no parity, the number of stop bits is 1 (non-standard) or 2. When changing the protocol, the change is made as soon as the Enter key is pressed.

Modbus Units

The Modbus Units menu is to control what units, where applicable, the meter's variables will be displayed in. Internal – these are the base units of the meter, °F, psia, lbm/sec, ft^3/sec, Btu/sec , lbm/ft^3 Display – variables are displayed in user selected display unit.

Modbus Order

The byte order within registers and the order in which multiple registers containing floating point or long integer data are transmitted may be changed with this menu item. According to the Modbus specification, the most significant byte of a register is transmitted first, followed by the least significant byte. The Modbus specification does not prescribe the order in which registers are transmitted when multiple registers represent values longer than 16 bits. Using this menu item, the order in which registers representing floating point or long integer data and/or the byte order within the registers may be reversed for compatibility with some PLCs and PC software.

The following four selections are available in this menu for byte order; when selecting an item, the protocol is changed immediately without having to press the ENTER key.

0-1:2-3	Most significant register first, most significant byte first (default)
2-3:0-1	Least significant register first, most significant byte first
1-0:3-2	Most significant register first, least significant byte first
3-2:1-0	Least significant register first, least significant byte first

Note: All of the registers are affected by the byte order, including strings and registers representing 16-bit integers; the register order only affects the order of those registers representing 32-bit floating point and long integer data, but does not affect single 16-bit integers or strings.

Modbus Protocol

The Modbus RTU protocol is supported in this implementation. Supported baud rates are 1200, 2400, 4800, 9600, 19200, 38400, 57600, and 115200. The default baud rate is 19200 baud. Depending upon the Modbus protocol selected, data are transmitted in 8-bit data frames with even or odd parity and 1 stop bit, or no parity and 2 or 1 (non-standard) stop bits.

The current Modbus protocol specification does not define register usage, but there is an informal register numbering convention derived from the original (now obsolete) Modicon Modbus protocol specification and used by many vendors of Modbus capable products.

Registers	Usage	Valid Function Codes
00001–09999	Read/write bits ("coils")	01 (read coils) 05 (write single coil) 15 (write multiple coils)
10001–19999	Read-only bits ("discrete inputs")	02 (read discrete inputs)
30001–39999	Read-only 16 bit registers ("input registers"), IEEE 754 floating point register pairs, arbitrary length strings encoded as two ASCII characters per 16-bit register	03 (read holding registers) 04 (read input registers)
40001–49999	Read/write 16-bit registers ("holding registers"), IEEE 754 floating point register pairs, arbitrary length strings encoded as two ASCII characters per 16-bit register	03 (read holding registers) 06 (write single register) 16 (write multiple registers)

Each range of register numbers maps to a unique range of addresses that are determined by the function code and the register number. The address is equal to the least significant four digits of the register number minus one, as shown in the following table.

Registers	Function Codes	Data Type and Address Range
00001-09999	01, 05, 15	Read/write bits 0000-9998
10001-19999	02	Read-only bits 0000-9999
30001-39999	03, 04	Read-only 16-bit registers 0000-9998
40001-49999	03, 06, 16	Read/write 16-bit registers 0000-9998

Register Definitions

The meter serial number and those variables that are commonly monitored (mass, volume and energy flow rates, total, pressure, temperature, density, viscosity, Reynolds number, and diagnostic variables such as frequency, velocity, gain, amplitude and filter setting) are accessible via the Modbus protocol. Long integer and floating point numbers are accessed as pairs of 16-bit registers in the register order selected in the Modbus Order menu. Floating point numbers are formatted as single precision IEEE 754 floating point values.

The flow rate, temperature, pressure, and density variables may be accessed as either the flow meter internal base units or in the user-programmed display units, which is determined by the programming Output Menu's "Modbus Units" item. The display units strings may be examined by accessing their associated registers. Each of these units string registers contain 2 characters of the string, and the strings may be 2 to 12 characters in length with unused characters set to zero. Note that the byte order affects the order in which the strings are transmitted. If the Modbus Order menu (see page 4-12) is set to 0-1:2-3 or 2-3:0-1, then the characters are transmitted in the correct order; if set to 1-0:3-2 or 3-2:1-0, then each pair of characters will be transmitted in reverse order.

Registers	Variable	Data type	Units	Function code	Addresses
65101-65102	Serial Number	unsigned long	—	03, 04	65100-65101
30525-30526	Totalizer	unsigned long	display units*	03, 04	524-525
32037-32042	Totalizer Units	string	—	03, 04	2036-2041
30009-30010	Mass Flow	float	display units*	03, 04	8-9
30007-30008	Volume Flow	float	display units*	03, 04	6-7
30005-30006	Pressure	float	display units*	03, 04	4-5
30001-30002	Temperature	float	display units*	03, 04	0-1
30029-30030	Velocity	float	ft/sec	03, 04	28-29
30015-30016	Density	float	display units*	03, 04	14-15
30013-30014	Viscosity	float	cP	03, 04	12-13
30031-30032	Reynolds Number	float	—	03, 04	30-31
30025-30026	Vortex Frequency	float	Hz	03, 04	24-25
34532	Gain	char	—	03, 04	4531
30085-30086	Vortex Amplitude	float	Vrms	03, 04	84-85
30027-30028	Filter Setting	float	Hz	03, 04	26-27
30035-30036	RTD Resistance (0)	float	ohms	03, 04	34-35
30037-30038	RTD Resistance (1)	float	ohms	03, 04	36-37
30073-30074	Max. Velocity	float	display units*	03, 04	72-73
30075-30076	Max. Temperature	float	display units*	03, 04	74-75
30077-30078	Max. Temperature (1)	float	display units*	03, 04	76-77
30079-30080	Max. Pressure	float	display units*	03, 04	78-79
30097-30098	Glycol Weight %	float	%	03, 04	96-97
30099-30100	External Loop mA	float	mA	03, 04	98-99
30101-30102	Differential Pressure	float	display units*	03, 04	100-101
30501-30502	Volume Total	unsigned long	display units*	03, 04	500-501
30503-30504	Mass Total	unsigned long	display units*	03, 04	502-503
31521	Digital Alarm State (0)	byte	—	03, 04	1520
31522	Digital Alarm State (1)	byte	—	03, 04	1521
31523	Digital Alarm State	byte	—	03, 04	1522

	(2)				
33001-33002	Simulated Vortex Frequency	float	—	03, 04	3000-3001
33003-33004	Simulated Temperature 0	float	—	03, 04	3002-3003
33005-33006	Simulated Temperature 1	float	—	03, 04	3004-3005
33007-33008	Simulated Pressure	float	—	03, 04	3006-3007
33009-33010	Insertion Pipe Diameter	float	—	03, 04	3008-3009
33101-33102	Unit per Pulse	float	—	03, 04	3100-3101
33115-33116	Ethylene Glycol %	float	—	03, 04	3114-3115
35001-35002	Meter Factor	float	—	03, 04	5000-5001
35003-35004	Low Flow Cutoff	float	—	03, 04	5002-5003
35005-35006	Ck	float	—	03, 04	5004-5005
38501-38502	Tag	string	—	03, 04	8500-8505

The following registers are available with the energy meter firmware:

Registers	Variable	Data type	Units	Function code	Addresses
30527-30528	Totalizer #2	unsigned long	display units*	03, 04	526-527
32043-32048	Totalizer #2 Units	string	—	03, 04	2042-2047
30003-30004	Temperature #2	float	display units*	03, 04	2-3
30011-30012	Energy Flow	float	display units*	03, 04	10-11
30017-30018	Fluid Enthalpy (0)	float	BTU/lb	03, 04	16-17
30019-30020	Fluid Enthalpy (1)	float	BTU/lb	03, 04	18-19
30191-30192	Delta Temperature	float	display units*	03, 04	190-191
30505-30506	Energy Total	unsigned long	display units*	03, 04	504-505
30507-30508	Reverse Energy Total	unsigned long	display units*	03, 04	506-507
30543-30544	Net Energy Total	unsigned long	display units*	03, 04	542-543

The following registers contain the display units strings:

Registers	Variable	Data type	Units	Function code	Addresses
32007-32012	Volume Flow Units	string	—	03, 04	2006-2011
32001-32006	Mass Flow Units	string	—	03, 04	2000-2005
32025-32030	Temperature Units	string	—	03, 04	2024-2029
32019-32024	Pressure Units	string	—	03, 04	2018-2023
32031-32036	Density Units	string	—	03, 04	2030-2035
32013-32017	Energy Flow Units	string	—	03, 04	2012-2017
32055-32060	Volume Total Units	string	—	03, 04	2054-2059
32061-32066	Mass Total Units	string	—	03, 04	2060-2065
32067-32072	Energy Total Units	string	—	03, 04	2066-2071

Function codes 03 (read holding registers) and 04 (read input registers) are the only codes supported for reading these registers, and function codes for writing holding registers are not implemented. We recommend that the floating point and long integer registers be read in a single operation with the number of registers being a multiple of two. If these data are read in two separate operations, each reading a single 16-bit register, then the value will likely be invalid.

The floating point registers with values in display units are scaled to the same units as are displayed, but are instantaneous values that are not smoothed. If display smoothing is enabled (non-zero value entered in the Display TC item in the Display Menu), then the register values will not agree exactly with the displayed values.

Exception Status Definitions

The Read Exception Status command (function code 07) returns the exception status byte, which is defined as follows. This byte may be cleared by setting “coil” register #00008 (function code 5, address 7, data = 0xff00).

Bit(s)	Definition
0-1	Byte order (see Modbus Order on page 4-12)
	0 = 3-2:1-0 1 = 2-3:0-1
	2 = 1-0:3-2 3 = 0-1:2-3
2	Not used
3	Not used
4	Not used
5	Not used
6	Not used
7	Configuration changed

Control Register Definitions

The only writeable registers in this implementation are the Reset Exception Status, Reset Meter and Reset Totalizer functions, which are implemented as ”coils” which may be written with the Write Single Coil command (function code 05) to address 0 through 9, respectively, (register #00001 through #00010). The value sent with this command must be either 0x0000 or 0xff00, or the meter will respond with an error message; the totalizer will be reset or exception status cleared only with a value of 0xff00.

The following registers contain the reset functions:

Registers	Variable	Value	Units	Function code	Coil #
00001	Reset Volume Total	0xFF00	—	05	0
00002	Reset Mass Total	0xFF00	—	05	1
00003	Reset Energy Total	0xFF00	—	05	2
00004	Reset Reverse Energy Total	0xFF00	—	05	3
00008	Reset Exception Status	0xFF00	—	05	7
00009	Reset Meter	0xFF00	—	05	8
00010	Reset Totals	0xFF00	—	05	9

Error Responses

If an error is detected in the message received by the unit, the function code in the response is the received function code with the most significant bit set, and the data field will contain the exception code byte, as follows:

Exception Code	Description
01	Invalid function code — function code not supported by device
02	Invalid data address — address defined by the start address and number of registers is out of range
03	Invalid data value — number of registers = 0 or > 125 or incorrect data with the Write Single Coil command

If the first byte of a message is not equal to the unit’s Modbus address, if the unit detects a parity error in any character in the received message (with even or odd parity enabled), or if the message CRC is incorrect, the unit will not respond.

Command Message Format

The start address is equal to the desired first register number minus one. The addresses derived from the start address and the number of registers must all be mapped to valid defined registers, or an invalid data address exception will occur.

Device Address	Function Code	Start Address	N = Number of Registers	CRC
8 bits, 1…247	8 bits	16 bits, 0…9998	16 bits, 1…125	16 bits

Normal Response Message Format

Device Address	Function Code	Byte Count = 2 x N	Data	CRC
8 bits, 1…247	8 bits	8 bits	(N) 16-bit registers	16 bits

Exception Response Message Format

Device Address	Function Code + 0x80	Exception Code	CRC
8 bits, 1…247	8 bits	8 bits	16 bits

Examples:

Read the exception status byte from the device with address 1:

```
01 07 41 E2


01 Device address
07 Function code, 07 = read exception status
41 E2 CRC
```

A typical response from the device is as follows:

```
01 07 03 62 31


01 Device address
07 Function code
03 Exception status byte
62 31 CRC
```

Request the first 12 registers from device with address 1:

```
01 04 00 00 00 0C F0 0F


01 Device address
04 Function code, 04 = read input register
00 00 Starting address
00 0C Number of registers = 12
F0 0F CRC
```

A typical response from the device is as follows:
**Note, these are the older register definitions

```
01 04 18 00 00 03 E8 00 00 7A 02 6C 62 00 00 41 BA 87 F2 3E BF FC 6F 42 12 EC
8B 4D D1


01 Device address
04 Function code
18 Number of data bytes = 24
00 00 03 E8 Serial number = 1000 (unsigned long)
00 00 7A 02 Totalizer = 31234 lbm (unsigned long)
6C 62 00 00 Totalizer units = "lb" (string, unused characters are 0)
41 BA 87 F2 Mass flow rate = 23.3164 lbm/sec (float)
3E BF FC 6F Volume flow rate = 0.3750 ft3/sec (float)
42 12 EC 8B Pressure = 36.731 psia (float)
4D D1 CRC
```

An attempt to read register(s) that don't exist:

```
01 04 00 00 00 50 F1 D2


01 Device address
04 Function code 4 = read input register
00 00 Starting address
00 50 Number of registers = 80
F0 36 CRC
```

Results in an error response as follows:

```
01 84 02 C2 C1


01 Device address
84 Function code with most significant bit set indicates error response
02 Exception code 2 = invalid data address
C2 C1 CRC
```

Request the state all three alarms:

```
01 02 00 00 00 03 38 0B


01 Device address
02 Function code 2 = read discrete inputs
00 00 Starting address
00 03 Number of inputs = 3
38 0B CRC
```

and the unit responds with:

```
01 02 01 02 20 49


01 Device address
02 Function code
01 Number of data bytes = 1
02 Alarm #2 on, alarms #1 and #3 off
20 49 CRC
```

To reset the totalizer:

```
01 05 00 00 FF 00 8C 3A


01 Device address
05 Function code 5 = write single coil
00 09 Coil address = 9
FF 00 Data to reset totalizer
5C 38 CRC
```

The unit responds with an identical message to that transmitted, and the totalizer is reset. If the "coil" is turned off as in the following message, the response is also identical to the transmitted message, but the totalizer is not affected.

```
01 05 00 09 00 00 1D C8


01 Device address
05 Function code 5 = write single coil
00 09 Coil address = 9
00 00 Data to "turn off coil" does not reset totalizer
1D C8 CRC
```

BACnet MS/TP Communications

Description

The BACnet Master-Slave/Token-Passing (MSTP) driver implements a data link protocol that uses the services of the RS-485 physical layer. The MS/TP bus is based on BACnet standard protocol SSPC-135, Clause 9. BACnet MS/TP protocol is a peer-to-peer, multiple master protocols based on token passing. Only master devices can receive the token, and only the device holding the token is allowed to originate a message on the bus. The token is passed from master device to master device using a small message. The token is passed in consecutive order starting with the lowest address. Slave devices on the bus only communicate on the bus when responding to a data request from a master device.

Wiring

An RS485 daisy chained network configuration as depicted below is recommended. Do not use a star, ring, or cluster arrangement.

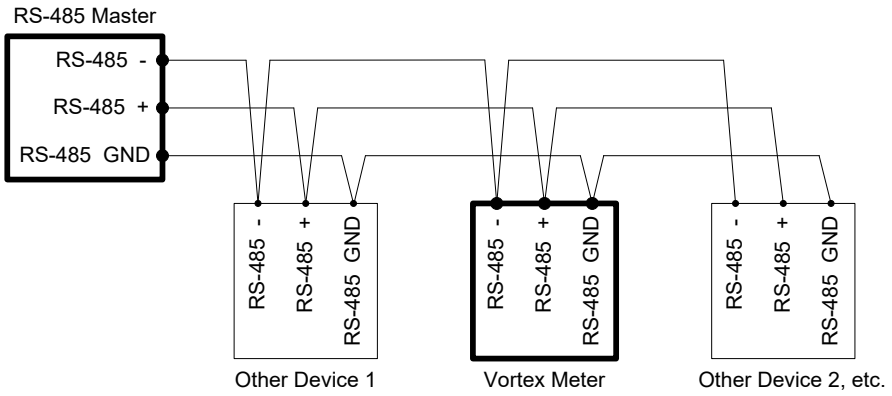


Figure 4.4 - RS-485 Wiring (BACnet)

Pin Labeling Among Devices

"RS-485 –" = "A" = "TxD-/RxD-" = "Inverting pin"

"RS-485 +" = "B" = "TxD+/RxD+" = "Non-Inverting pin"

"RS-485 GND" = "GND" = "G" = "SC" = "Reference"

Baud Rates on the MS/TP Bus

An MS/TP bus can be configured to communicate at one of four different baud rates. It is very important that all of the devices on an MS/TP bus communicate at the same baud rate. The baud rate setting determines the rate at which devices communicate data over the bus. The baud rate settings available on FlowCalc™ Flow Computers are 9600, 19200 and 38400.

Baud Rate and MAC Address Configuration Setup

1. Power on the IUT.
2. Enter the factory password 16363 (Use UP and DOWN arrows to enter the digits).
3. Navigate with the left arrow to Diagnostics Menu.
4. Press ENTER and press RIGHT button immediately.
5. Navigate to Config Code screen by continuous pressing DOWN button.
6. After reaching Config Code screen, press RIGHT to navigate to Comm. Type screen.
7. Press ENTER and change the Comm. Type to "BACnet." Press ENTER to save.

Note: BACnet will enable Baud Rate and MAC address screens

8. Press EXIT twice to go back to the Diagnostics Menu.
9. Navigate to Output Menu by using RIGHT or LEFT arrow buttons.
10. Press DOWN button and reach Baud Rate and MAC address screens.
11. Change the required settings and press EXIT & ENTER button to save the configuration.
12. Reboot the device by power off and on for the changes to take effect.

Note:

a. IUT support 9600, 19200, 38400 baud rates

b. MAC address range is 0-127

Supported BACnet Objects

A BACnet object represents physical or virtual equipment information, as a digital input or parameters. The FlowCalc™ Flow Computer presents the following object types:

1) Device Object
2) Analog Input
3) Binary Input
4) Binary Value

Each object type defines a data structure composed of properties that allow the access to the object information. The below table shows the implemented properties for each Vortex Mass Flow Meters object type.

Properties	Object Types			
	Device	Analog Input	Binary Input	Binary Value
Object_Identifier	☑	☑	☑	☑
Object_Name	☑	☑	☑	☑
Object_Type	☑	☑	☑	☑
System_Status	☑			
Vendor_Name	☑			
Vendor_Identifier	☑			
Model_Name	☑			
Firmware_Revision	☑			
Application-Software-Version	☑			
Protocol_Version	☑			
Protocol_Revision	☑			
Protocol_Services_Supported	☑			
Protocol_Object_Types_Supported	☑			
Object_List	☑			
Max_ADPU_Length_Accepted	☑			
Segmentation_Supported	☑			
ADPU_Timeout	☑			
Number_Of_ADPU_Retries	☑			
Max_Masters	☑			
Max_Info_Frames	☑			
Device_Address_Binding	☑			
Database_Revision	☑			
Status_Flags				
Event_State		☑	☑	☑
Reliability				
Out_Of_Service		☑ (W)	☑ (W)	☑ (W)
Units		☑		
Polarity			☑ (W)	
Priority_Array				
Relinquish_Default				
Status_Flag		☑	☑	☑
Present_Value		☑ (W)	☑ (W)	☑ (W)
Inactive_Text				
Active_Text				

(W) – Writable Property.

Device Object

The Device object default property values are as follows:

Property Name	Default Values
object-identifier	7
object-name	Device,1
object-type	Device
system-status	operational
vendor-name	VorTek Instruments
vendor-identifier	558
model-name	Multivariable Flowmeter
firmware-revision	N/A
application-software-version	1.07
protocol-version	1
protocol-revision	4
protocol-services-supported	{F,F,F,F,F,F,F,F,F,F,F,F,T,F,T,T,T,T,F,F,F,F,F,F,F,F,F,F,F,T,T,F,F,F,F,F}
protocol-object-types-supported	{T,F,F,T,F,T,F,F,T,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F}
object-list	{(analog-input,1),(analog-input,2),(analog-input,3),(analog-input,4), (analog-input,5), (analog-input,6),(analog-input,7),(analog-input,8) (analog-input,9),(analog-input,10), (analog-input,11), (analog-input,12), (analog-input,13),(analog-input,14), (analog-input,15),(analog-input,16),(analog-input,17), (analog-input,18),(analog-input,19),(binary-input,1),(binary-input,2),(binary-input,3),(binary-input,4), (binary-value,1), (device,7) }
max-apdu-length-accepted	300
segmentation-supported	no-segmentation
apdu-timeout	3000
number-of-APDU-retries	1
max-master	127
max-info-frames	1
device-address-binding	()
database-revision	0

Note - Device Communication Control: Password – “vortek”

Analog Input Object

Vortex Mass Flow Meters Analog Input type objects are described below:

Object Instance	Object Name	Unit	Description
1	Volume Flow	cubic-feet-per-second, cubic-feet-per-minute, us-gallons-per-minute, imperial-gallons-per-minute, liters-per-minute, liters-per-second, liters-per-hour, cubic-meters-per-second, cubic-meters-per-minute, cubic-meters-per-hour	This AI object is used to measure volume flow.
2	Mass Flow	pounds-mass-per-second, grams-per-second, kilograms-per-second , kilograms-per-minute , kilograms-per-hour, pounds-mass-per-minute , pounds-mass-per-hour, tons-per-hour, grams-per-second , grams-per-minute	This AI object is used to measure mass flow.
3	Temperature 1	degrees-Celsius, degrees-Kelvin, degrees-Fahrenheit	This AI object measures Temperature in one of the given Unit.
4	Temperature 2	degrees-Celsius, degrees-Kelvin, degrees-Fahrenheit	This AI object measures Temperature in one of the given Unit.
5	Pressure	pounds-force-per-square-inch, inches-of-water, inches-of-mercury, millimeters-of-mercury, bars, millibars, pascals, kilopascals	TBD
6	Density	kilograms-per-cubic-meter	TBD
7	Energy Flow	Kilowatts, Horsepower, btus-per-hour, kilo-btus-per-hour, megawatts	TBD
8	Totalizer 1 & Totalizer 2	If Totalizer selection for Mass measure – pounds-mass-per-second, grams-per-second, kilograms-per-second,	An electronic counter which records the total accumulated flow over a certain range of time.

		kilograms-per-minute, kilograms-per-hour, pounds-mass-per-minute, pounds-mass-per-hour, tons-per-hour, grams-per-second, grams-per-minute If Totalizer selection for Volume measure – cubic-feet-per-second, cubic-feet-per-minute, us-gallons-per-minute, imperial-gallons-per-minute, liters-per-minute, liters-per-second, liters-per-hour, cubic-meters-per-second, cubic-meters-per-minute, cubic-meters-per-hour If Totalizer selection for Energy measure – Kilowatts, Horsepower, btus-per-hour, kilo-btus-per-hour, megawatts	
10	StatusRegister	NO UNITS	TBD
11	Channel 1 (4-20mA)	milliamperes	TBD
12	Channel 2 (4-20mA)	milliamperes	TBD
13	Channel 3 (4-20mA)	milliamperes	TBD
14	Scaled Freq	hertz	TBD
15	Flow Velocity	feet-per-second	TBD
16	Viscosity	centipoises	TBD
17	Frequency	hertz	TBD
18	Vortex Amp	millivolts	TBD
19	FilterSetting	hertz	TBD

Binary Input Object

Vortex Mass Flow Meters Binary Input type objects are described below:

Object Instance	Object Name	Description
1	Alarm1	The status of the three alarms may be monitored via the Modbus command. The value returned indicates the state of the alarm and will be 1 only if the alarm is enabled and active. A zero value is transmitted for alarms that are either disabled or inactive
2	Alarm2	
3	Alarm3	
4	External	TBD

Note - Binary Input 4, Present value always read zero, because no information available from client, so the polarity property doesn't impact on Present value property when the Out of service property is false.

Binary Value Object

Vortex Mass Flow Meters Binary Value type objects are described below:

Object Instance	Object Name	Description
1	Reset	Resets Totalizer

ANNEX – BACnet Protocol Implementation Conformance Statement

Date: 19-April-2012

Vendor Name: VorTek Instruments

Product Name: FlowCalc™ Flow Computer

Product Model Number: M22/M23/M24 VT/VTP

Applications Software Version: 1.07

Firmware Revision: N/A

BACnet Protocol Revision: 4

Product Description: VorTek multivariable flow-meter

Annex L – BACnet Standardized Device Profile

☐ BACnet Operator Workstation (B-OWS)

☐ BACnet Advanced Operator Workstation (B-AWS)

☐ BACnet Operator Display (B-OD)

☐ BACnet Building Controller (B-BC)

☐ BACnet Advanced Application Controller (B-AAC)

☑ BACnet Application Specific Controller (B-ASC)

☐ BACnet Smart Sensor (B-SS)

☐ BACnet Smart Actuator (B-SA)

Annex K – All BACnet Interoperability Building Blocks Supported

BIBBs
DS-RP-B
DS-WP-B
DM-DDB-B
DM-DOB-B
DM-DCC-B
DS-RPM-B
DS-WPM-B

Services Supported	
Read Property	Execute
Write Property	Execute
Read Property Multiple	Execute
Write Property Multiple	Execute
Who-Is	Execute
I-Am	Initiate
Who-Has	Execute
I-Have	Initiate
Device Communication Control	Execute

Segmentation Capability:

☐ Able to transmit segmented messages Window Size

☐Able to receive segmented messages Window Size

Standard Object Types Supported

Standard Object Types Supported				
Object Type	**Dynamically Creatable**	**Dynamically Delete-able**	**Additional Writable Properties**	**Range Restrictions**
Analog Input (AI)	No	No	None	None
Binary Input (BV)	No	No	None	None
Binary Value	No	No	None	None
Device	No	No	None	None

Standard Object Types Supported Writable Properties			
Object Type	**Properties**		
Analog Input (AI)	Present Value	Out-Of-Service	
Binary Input (BV)	Present Value	Out-Of-Service	Polarity
Binary Value	Present Value	Out-Of-Service	
Device			

Object List

Properties of Analog Input/Value Objects Type						
ID	Name	Present Value	Status Flags	Event State	Out of Service	Units
AI1	Volume Flow	?	F,F,F,F	Normal	False	?
AI2	Mass Flow	?	F,F,F,F	Normal	False	?
AI3	Temperature 1	?	F,F,F,F	Normal	False	?
AI4	Temperature 2	?	F,F,F,F	Normal	False	?
AI5	Pressure	?	F,F,F,F	Normal	False	?
AI6	Density	?	F,F,F,F	Normal	False	?
AI7	Energy Flow	?	F,F,F,F	Normal	False	?
AI8	Totalizer 1	?	F,F,F,F	Normal	False	?
AI9	Totalizer 2	?	F,F,F,F	Normal	False	?
AI10	StatusRegister	?	F,F,F,F	Normal	False	?
AI11	Channel 1 (4-20mA)	?	F,F,F,F	Normal	False	?
AI12	Channel 2 (4-20mA)	?	F,F,F,F	Normal	False	?
AI13	Channel 3 (4-20mA)	?	F,F,F,F	Normal	False	?
AI14	Scaled Freq	?	F,F,F,F	Normal	False	?
AI15	Flow Velocity	?	F,F,F,F	Normal	False	?
AI16	Viscosity	?	F,F,F,F	Normal	False	?
AI17	Frequency	?	F,F,F,F	Normal	False	?
AI18	Vortex Amp	?	F,F,F,F	Normal	False	?
AI19	FilterSetting	?	F,F,F,F	Normal	False	?

Properties of Analog Input/Value Objects Type						
ID	Name	Present Value	Status Flags	Event State	Out of Service	Polarity
BI1	Alarm1	?	F,F,F,F	Normal	False	Normal
BI2	Alarm2	?	F,F,F,F	Normal	False	Normal
BI3	Alarm3	?	F,F,F,F	Normal	False	Normal
BI4	External	?	F,F,F,F	Normal	False	Normal

Properties of Analog Input/Value Objects Type						
ID	Name	Present Value	Status Flags	Event State	Out of Service	Out of Service
BV1	Reset	?	F,F,F,F	Normal	False	False

Data Link Layer Options

☐BACnet IP, (Annex J)

☐BACnet IP, (Annex J), Foreign Device

☐ISO 8802-3, Ethernet (Clause 7)

☐ANSI/ATA 878.1, 2.5 Mb. ARCNET (Clause 8)

☐ANSI/ATA 878.1, EIA-485 ARCNET (Clause 8), baud rate(s)

☑MS/TP master (Clause 9), baud rate(s): 9600, 19200, 38400

☐MS/TP slave (Clause 9), baud rate(s):

☐Point-To-Point, EIA 232 (Clause 10), baud rate(s):

☐Point-To-Point, modem, (Clause 10), baud rate(s):

☐LonTalk, (Clause 11), medium:

☐Other:

Device Address Binding
Is static device binding supported? (This is currently necessary for two-way communication with MS/TP slaves and certain other devices.):

☐Yes

☑No

Networking Options
☐ Router, Clause 6 - List all routing configurations, e.g., ARCNET-Ethernet, Ethernet-MS/TP, etc.

☐ Annex H, BACnet Tunneling Router over IP

☐ BACnet/IP Broadcast Management Device (BBMD)

Does the BBMD support registrations by Foreign Devices?

☐ Yes ☐ No

Does the BBMD support network address translation?

☐ Yes ☐ No

Network Security Options
☐ Non-secure Device - is capable of operating without BACnet Network Security

☐ Secure Device - is capable of using BACnet Network Security (NS-SD BVBB)

☐ Multiple Application-Specific Keys:

☐ Supports encryption (NS-ED BVBB)

☐ Key Server (NS-KS BVBB)

Character Sets Supported
Indicating support for multiple character sets does not imply that they can all be supported simultaneously.

☑ ANSI X3.4	☐IBM™/Microsoft™DBCS
☐ISO 8859-1	☐ISO 10646 (UCS-2)
☐ISO 10646 (UCS-4)	☐JIS C 6226

If this product is a communication gateway, describe the types of non-BACnet equipment/networks(s) that the gateway supports: N/A

Acronyms and Definitions

Item	Description
APDU	Application Protocol Data Unit
BACnet	Building Automation and Control Network- Data communication protocol
MS/TP	Master-Slave Token passing (a twisted pair RS485 network created by BACnet)
BIBB	BACnet Interoperability Building Block (Specific individual function blocks for data exchange between interoperable devices).
BV	Binary Value
BI	Binary Input
AI	Analog Input
RP	Read Property
WP	Write Property
RPM	Read Property Multiple
WPM	Write Property Multiple.
DDB	Dynamic Device Binding
DOB	Dynamic Object Binding
DCC	Device communication Control

POE Communications

Direct Connection Options

The unit must be powered by DC power or ethernet cable (see page 15-16). If using DC powering option, connect a standard ethernet cable to your PC and the unit. If using POE, ensure the switch is connected to your PC.

For testing and initial setup purposes, one may use direct connection to PC or Laptop. After reconnecting, you need to cycle the power to the meter. The meter will display the current IP address on the screen. Once the unit is connected it will try to request an IP address from the nonexistent DHCP server and then switch to AutoIP address (unfortunately random), for example 169.254.xxx.xxx.

If you could not see the IP address after cycling the meters power, you can run the IPSetup utility program. See more instructions on how to use the IPSetup program below in Network Configuration (see page 4-36). Once you find out assigned meter IP address or the NetBios name http://VRTXXXXX, type one of them into a browser to connect to the unit.

Connection Issues

The common issue is that PC does not recognize the plugged Ethernet cable. You may have to disable/enable Ethernet adapter to force it to “see” connected cable.

Alternatively, you may use static IP setting for both your PC and meter. The addresses should be on the same network, like 192.168.1.xxx or 10.10.10.xxx.

Tip: To quickly find Microsoft Network configuration page, type WindowsKey+R and in command window enter “ncpa.cpl”

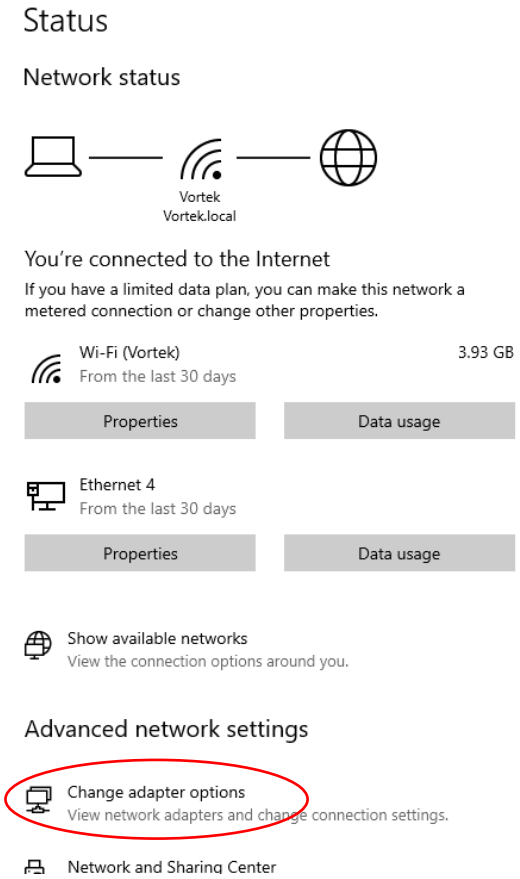
Network Configuration

Vortek/TCP meter needs to be configured in order to be "visible" on your local network. There are two methods of configuration:

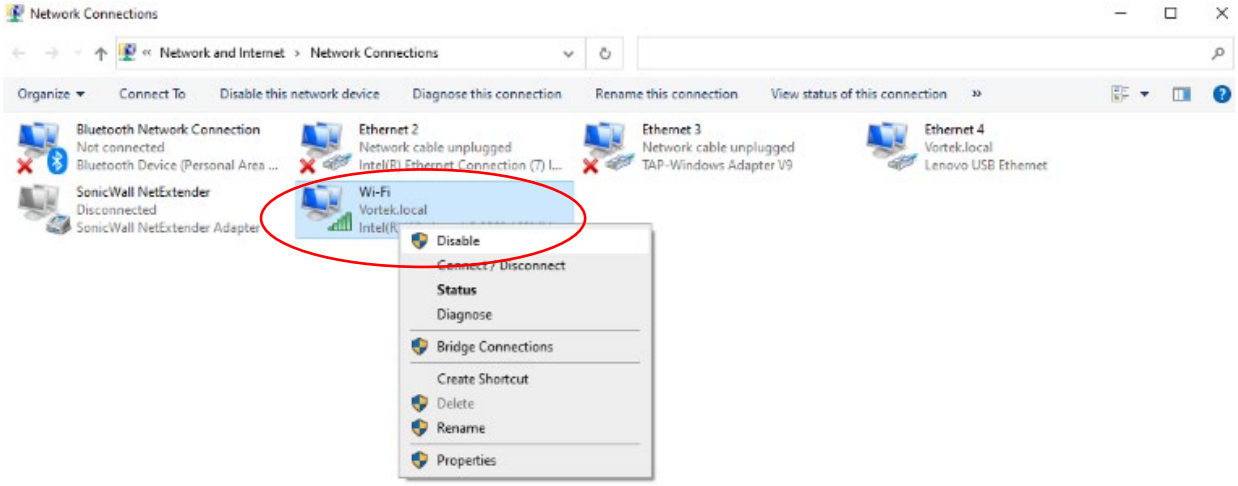
- Static IP address
- Dynamically assigned IP address via DHCP (Dynamic Host Configuration Protocol)

For static configuration consult your network administrator which IP address to use. To set up your Static IP address on Windows, follow the below instructions.

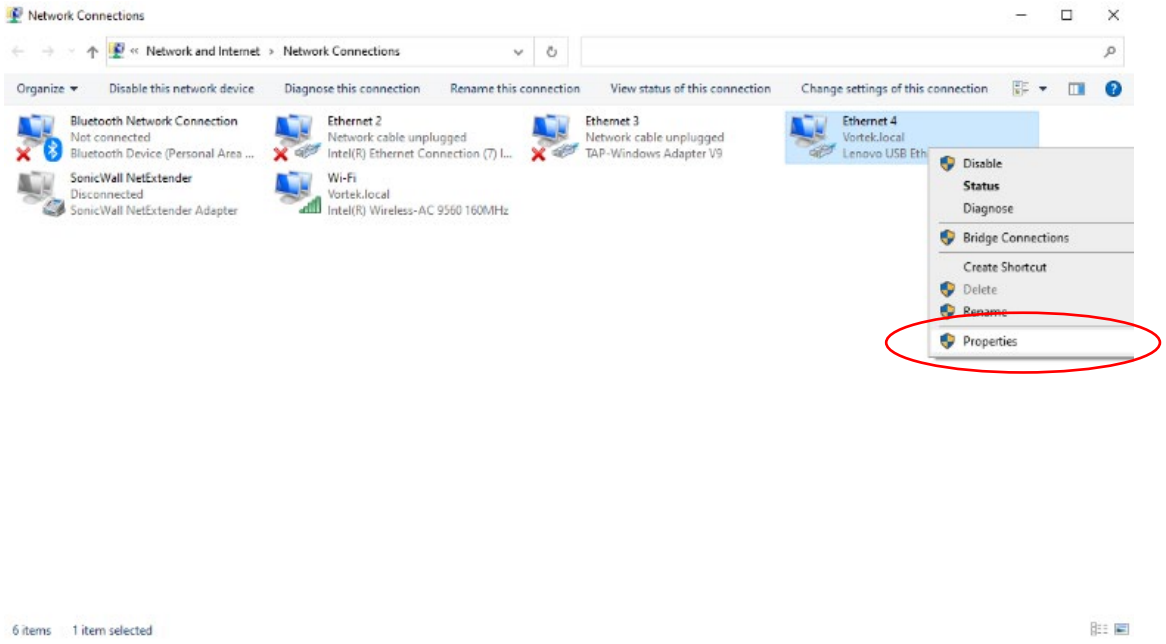
1. Open your "Network and Internet Settings" and then click on "Change adapter options."



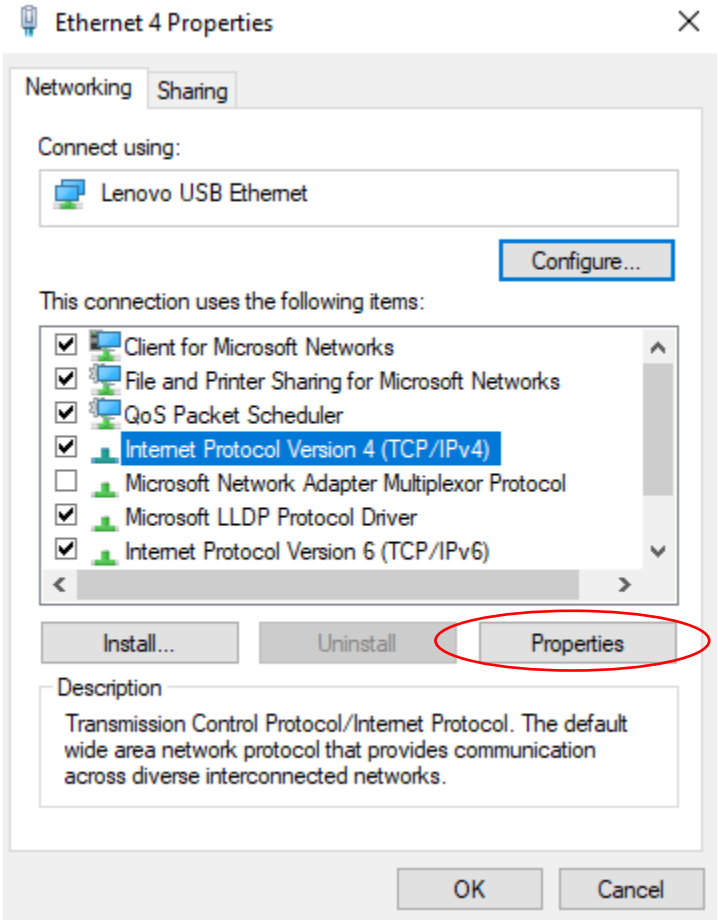
2. Right click on “Wireless Network Connection” and then click “Disable.”



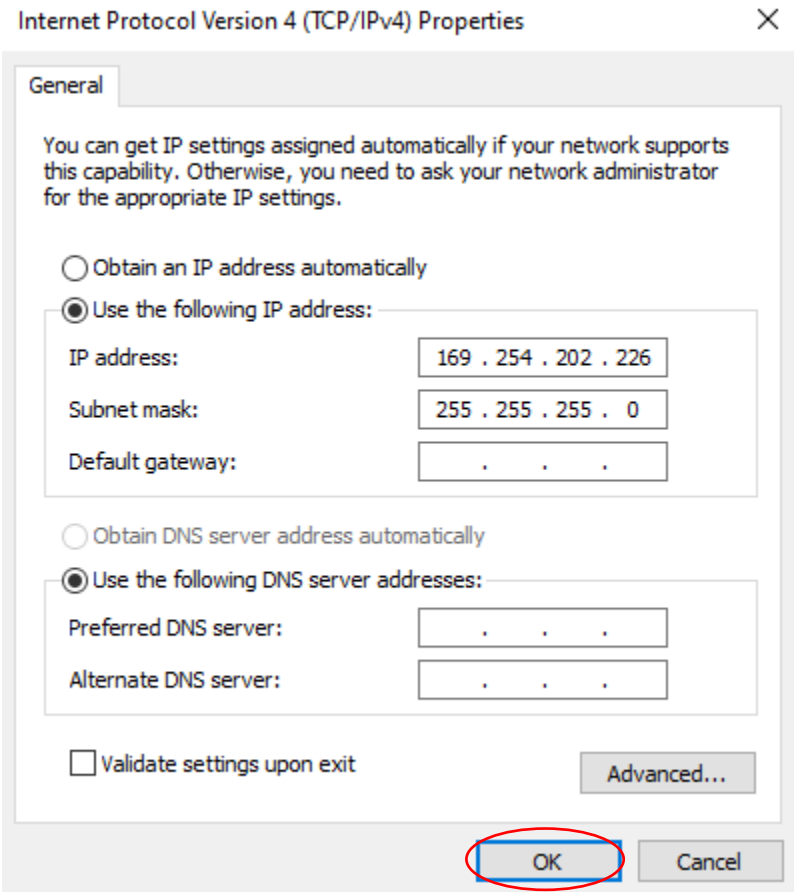
3. Right click on “Ethernet” and then select “Properties.”



4. Click on “Internet Protocol Version 4 (TCP/IPv4)” and select “Properties.”



5. The below window will be displayed. Fill in the following information and then click "OK."
    a. Select "Use the following IP address."
    b. Enter the IP address you wish to use. The IP address cannot be the same as the device IP address you are connecting to. Change the last set of digits by one.
        i. Example: If your device IP address is 169.254.202.225, then set your Static IP address to 169.254.202.226.
    c. Enter the Subnet Mask. This is the exact same as the device you are connecting to.
    d. Enter the Default Gateway (optional). If you do not know the Default Gateway, leave this field blank.



6. Once your Static IP address is set, make sure to go back to "Internet Protocol Version 4 (TCP/Pv4)" "Properties" and select "Obtain an IP address automatically." Also, "Enable" your "Wireless Network Connection" so that you can connect back to wireless networks.

IPSetup Network Configuration Tool

IPSetup is used to configure network settings on your Vortek/TCP device such as IP Address, Mask, Gateway, and DNS Server. If enabled in your device, IPSetup uses a User Datagram Protocol (UDP) broadcast on port 20034 to identify Vortek/TCP network devices. UDP broadcasts are not forwarded by routers, so IPSetup can only be used on a LAN or direct connection. You need to run it on a PC connected to the same switch as your device.

IP Setup is commonly used for:

- Determining the DHCP assigned IP address of your device.
- Configuring the network settings of your device.

IPSetup can be downloaded from the Vortek website (Documents & Downloads). This program can run on any Windows or Linux machine under Windows emulator WINE.

Configuring the Meter with IPSetup

IPSetup/Configuration should only need to be done at initial commissioning on the customer's network.

Before you begin, please ensure the device is on the same LAN or directly connected to a PC.

To configure a device with IPSetup, follow the below instructions once opening the IPSetup tool.

1. Click on a device in the “Select a Unit” window. Note, each unit has been assigned a unique identifier code that begins with the VRTX as seen below. Also, the meter will display the current IP address upon powering up the meter.

2. Enter your configuration settings in the “NDK Settings” group. Configuration can either be set up as a static IP address assigned by your network administrator or can be set up to DHCP by setting the IP address to 0.0.0.0.

3. Once you have specified all your configuration settings, click on the “Set” button to transmit them to your device. Please Note: Besides IP, Network Mask, GateWay and DNS, do not change any other parameters, such as Uart, delay, baud rate, etc. Correct GateWay settings are necessary if you are planning to access device from the Internet or other subnets of your local network.

4. The DHCP assigned address, or static IP address, will appear in the description next to each Vortek/TCP device in the Select a Unit window.

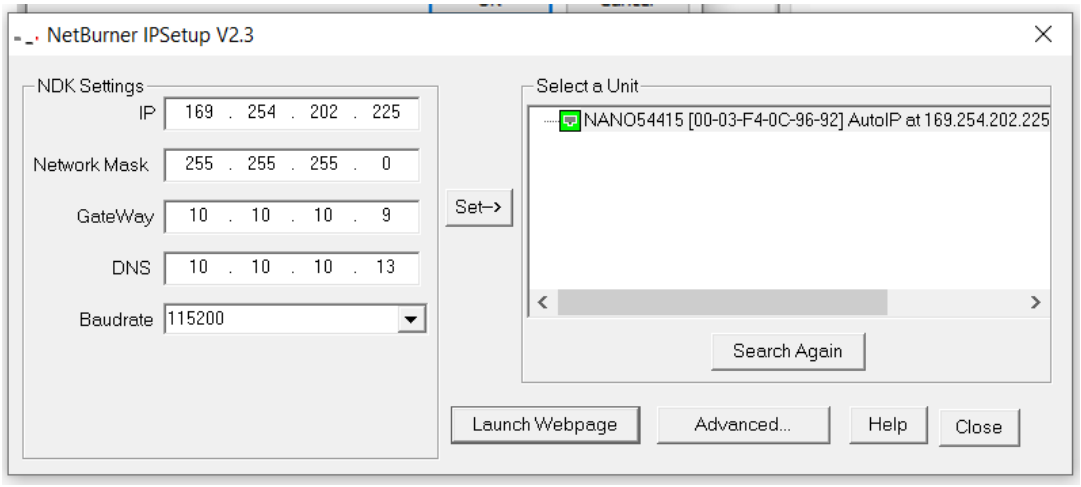


Figure 4.5 – IPSetup Displaying the Current IP Address

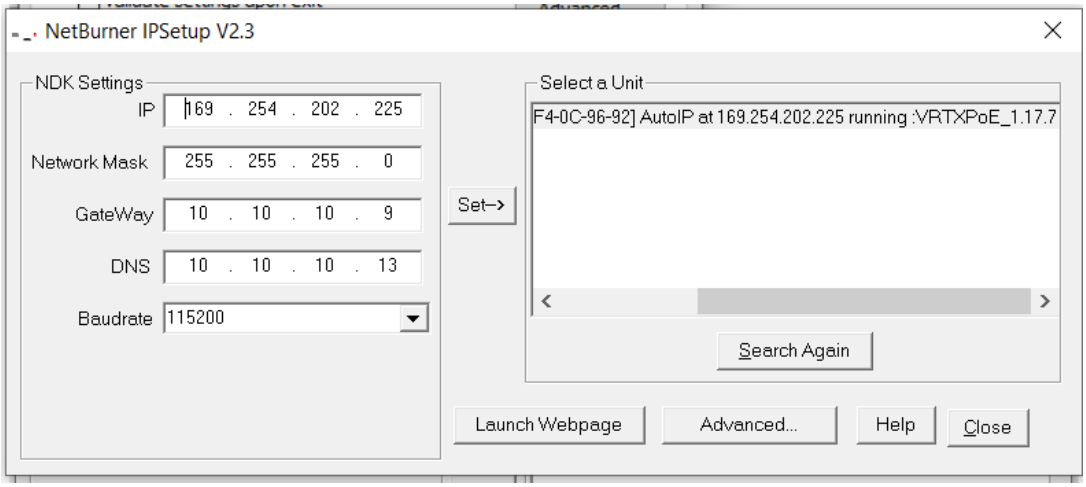


Figure 4.6 - IPSetup Displaying the Unique Identifier Code VRTX (NetBIOS Name)

IPSetup Does Not Display Your VorTek/TCP Device

If IPSetup does not display your device, the issue could be one of the following:

- A firewall on your PC is blocking network port number 20034. Try temporarily disabling your firewall and try again.
- If you are trying to talk to a device on the other side of a router. Check to see if the PC and Vortek/TCP devices are on the same LAN.

IPSetup FAQ

- If DHCP serve can't assign an address to the meter, it will switch to AutoIP. AutoIPs are special addresses in the range 169.254.XXX.XXX. The XXX.XXX values are randomly selected with an attempt to avoid duplication. AutoIP is used for DIRECT CONNECTION to a PC.
- IPSetup shows the name of the application as shown on Figure 4.5 and 4.6 above. The name is composed of letters VRTX and 4 last HEX digits of unit's MAC address. For example: VRTX9692 also referred to as the NetBIOS name.
- You may access the unit by typing the name in the address field of WEB browser, for example: http://VRTX9692. This works on Microsoft computers and may not work on Linux machines. For Linux machines it needs to have SMB protocol enabled to understand the NetBios names. You can also type the IP address of the device directly into the WEB browser, for example: 169.254.202.225

Tip: there is linux nmblookup command, which shows IP address by NetBios name.

- It is recommended to provide a correct GateWay address. DNS is necessary only if access to the Internet is needed for the device. in case, for example, accessing Network Time Servers. It may be set as 0.0.0.0.

Meter WEB Pages

VRTX meter has an internal WEB server providing real time measurement information and a configuration interface. It is recommended to use Google Chrome or Microsoft Edge when using the WEB pages.

The meter supports two protocols for accessing the WEB pages:

- HTTP – insecure connection to TCP port 80
- HTTPS – secure connection to configuration pages on TCP port 443.

It is possible to connect to all pages using HTTPS instead of HTTP. The assumption is that measurement data does not need to be secure, while configuration must be always encrypted.

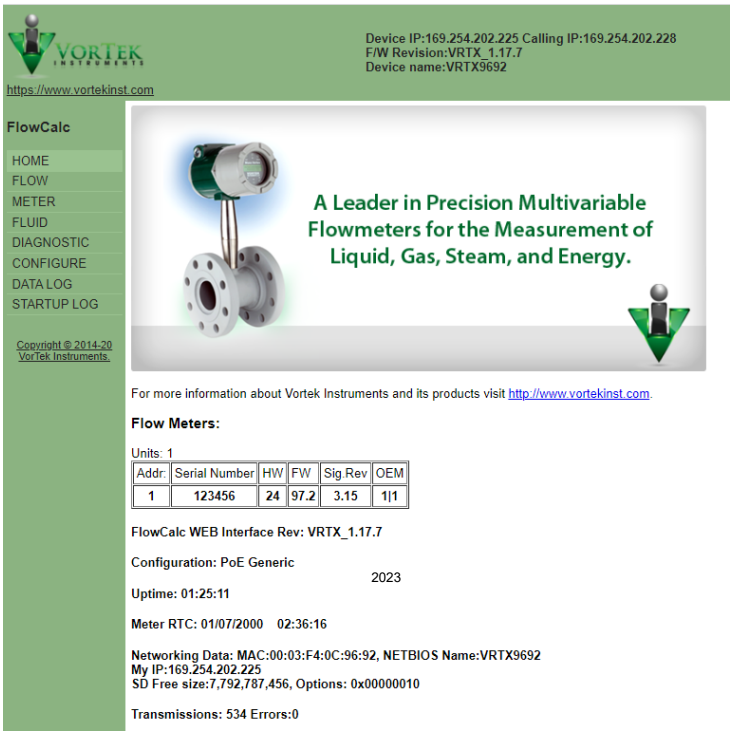


Figure 4.7 - Main/Home Page

Above is a Figure of the main page of the webpage with the menu selections on the left side. When the meter is initially powered up, it scans for connected meters. This version is intended for master/slave configuration with multiple meters connected to a single gateway. Normally this Slave Address selector is not used and there is always only one selection possible.

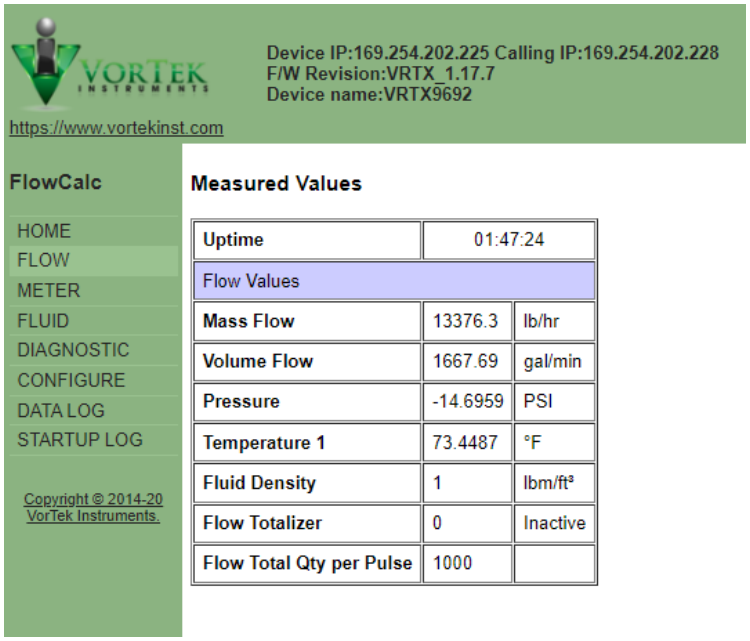


Figure 4.8- Flow Menu

The above figure displays what values are available on the Flow Menu.

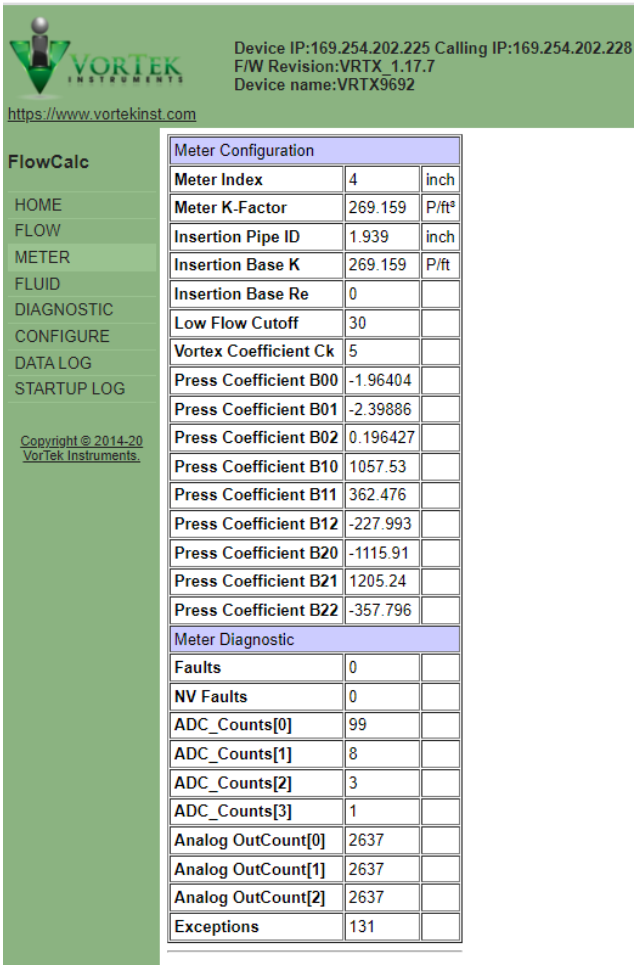


Figure 4.9 - Meter Menu

The above figure displays what values are available in the Meter Menu.

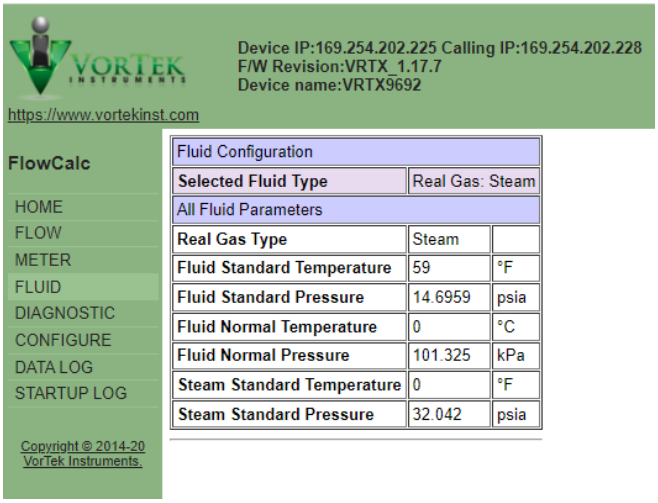


Figure 4.10 - Fluid Menu

The above figure displays the values of the Fluid Menu.

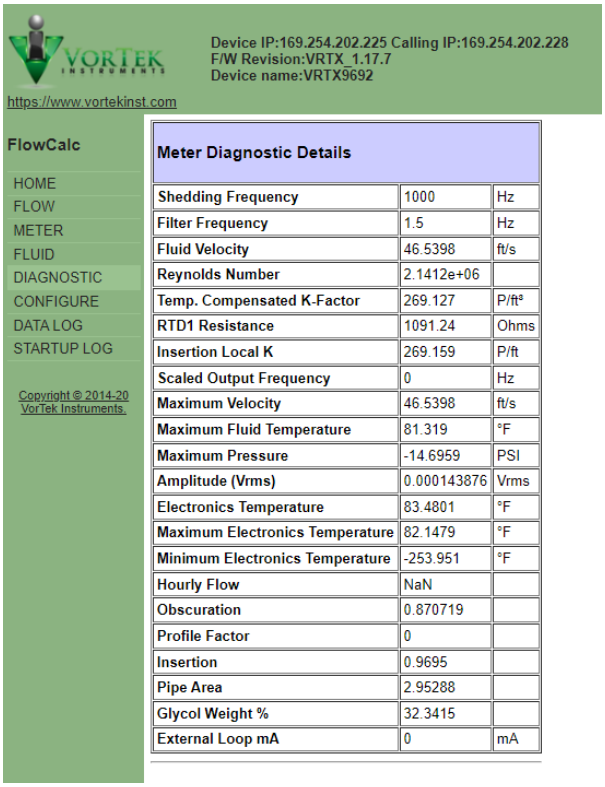


Figure 4.11 - Diagnostic Menu

The above figure shows the values of the Diagnostics Menu.

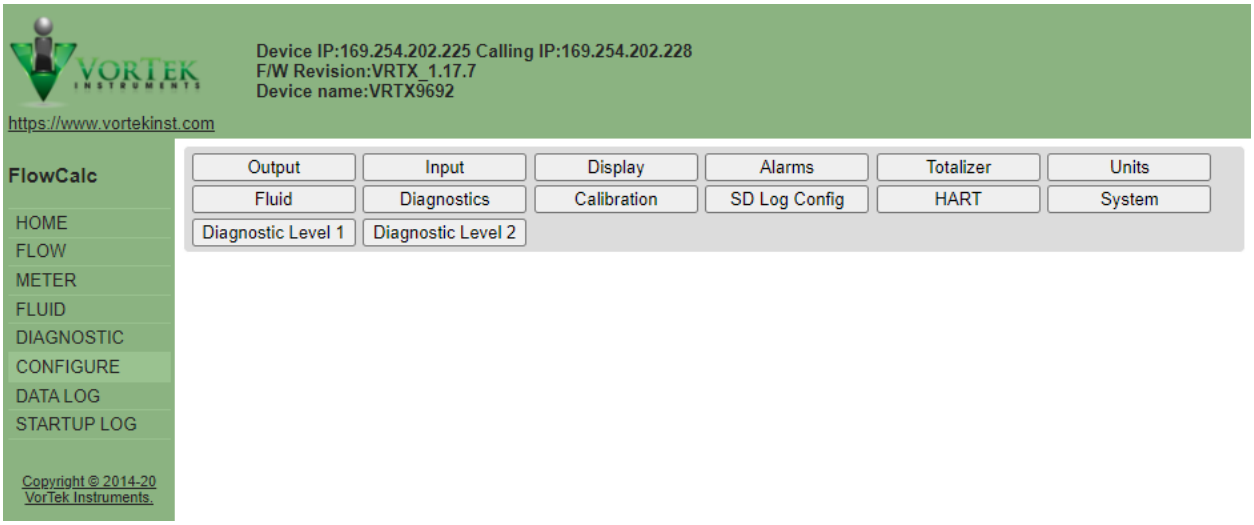


Figure 4.12 - Configure Menu

The above figure shows the Configure page options. You may see the following screen if this is the first time accessing the WEB page for the meter. The Username is “creator” and the Password is 16363.

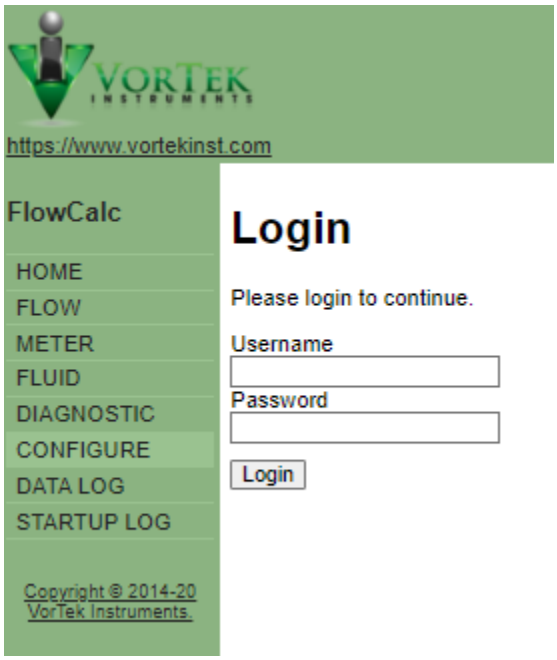


Figure 4.13 - Configure Password Protection

Figure 4.14 - Data log Menu

The above figure shows the Data Log options.

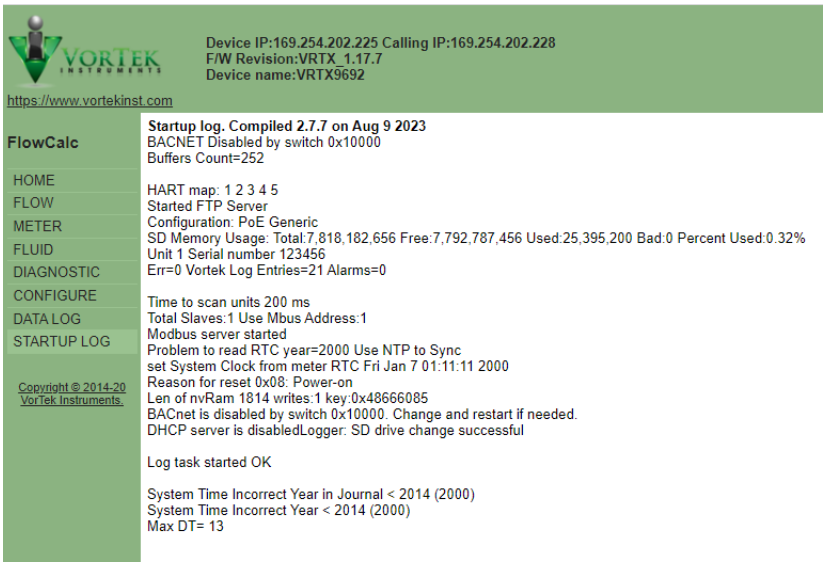


Figure 4.15 - Startup Log Menu

The figure above shows the Startup Log page.

WEB Configuration Interface

When access tabs in the Configure Page, you will need to enter the Username and Password.

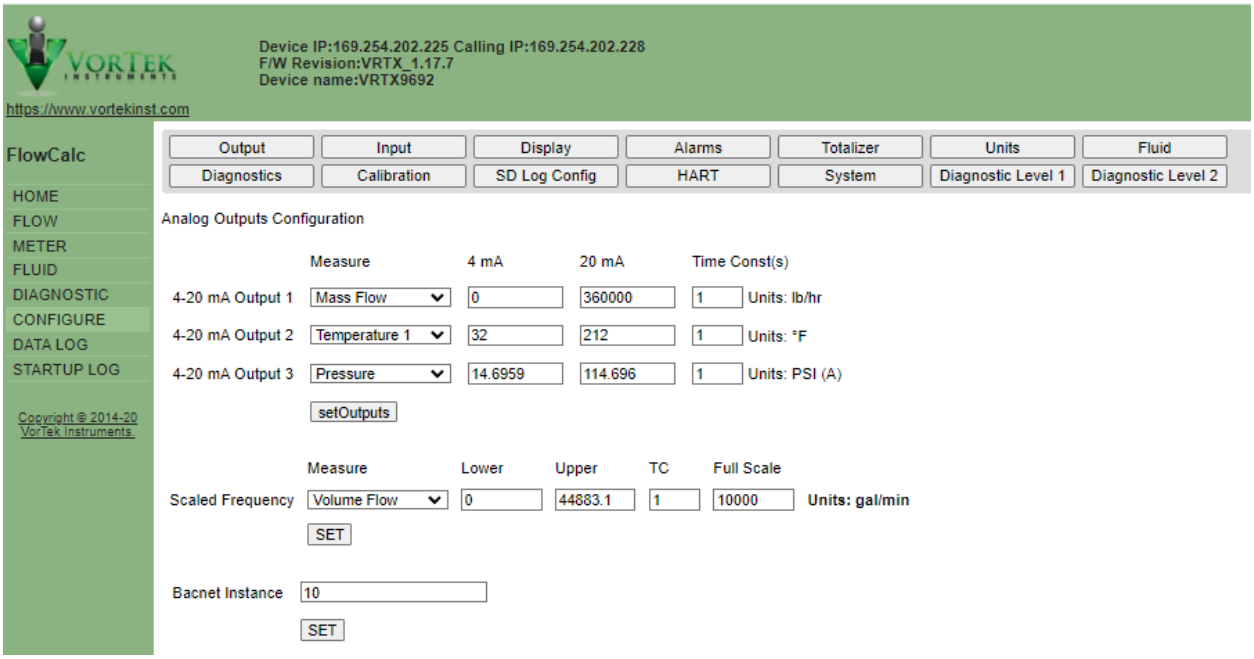


Figure 4.16 - Output Tab

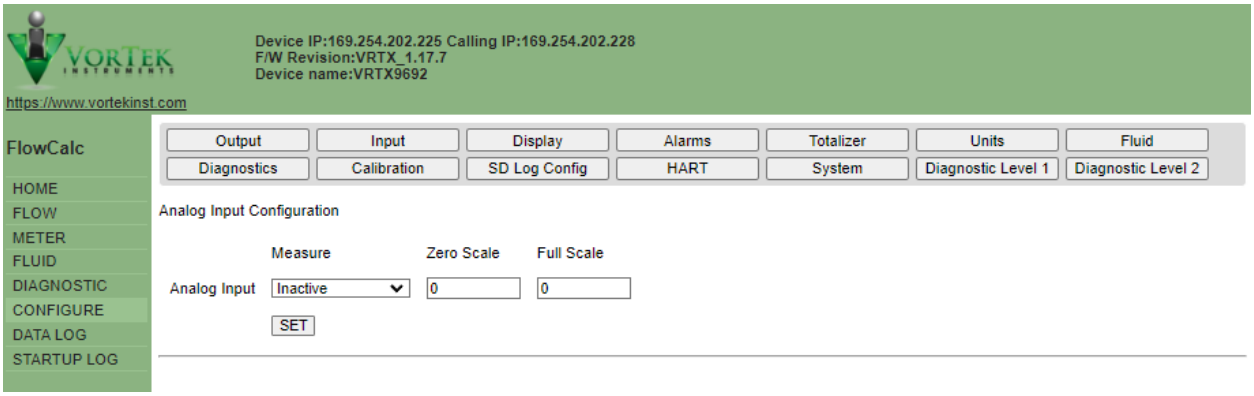


Figure 4.17 – External Input Tab

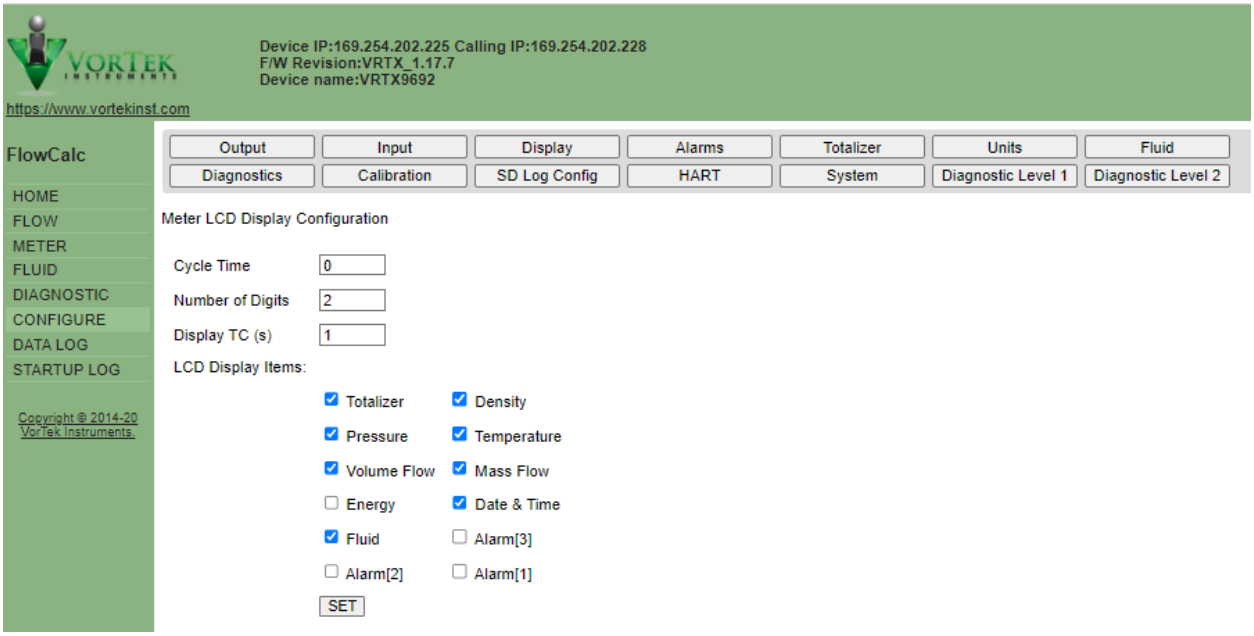


Figure 4.18 - Display Tab

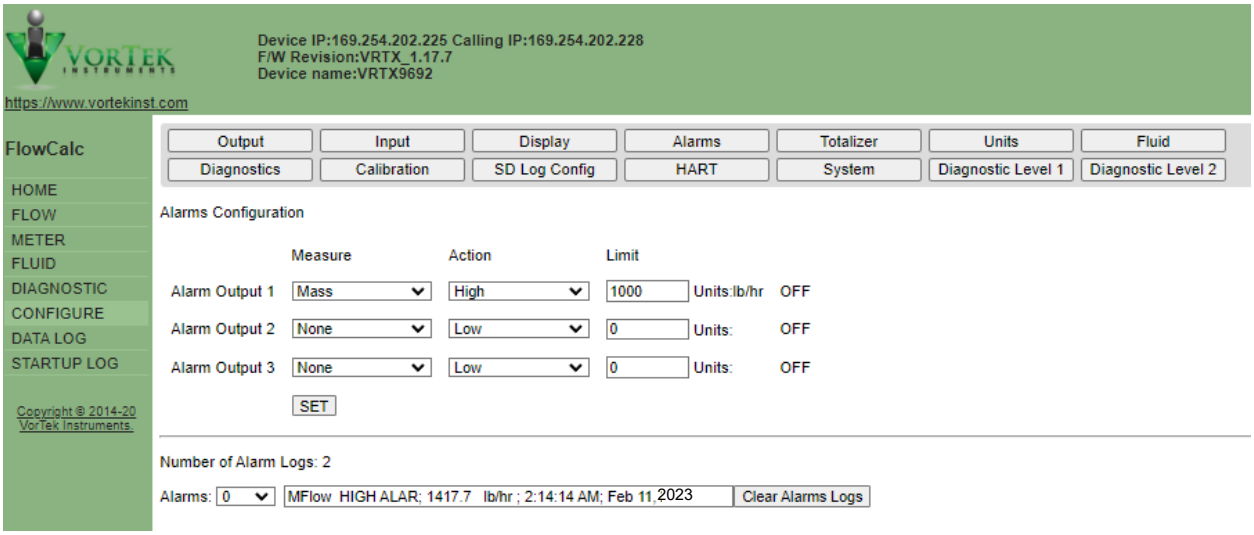


Figure 4.19 - Alarms Tab

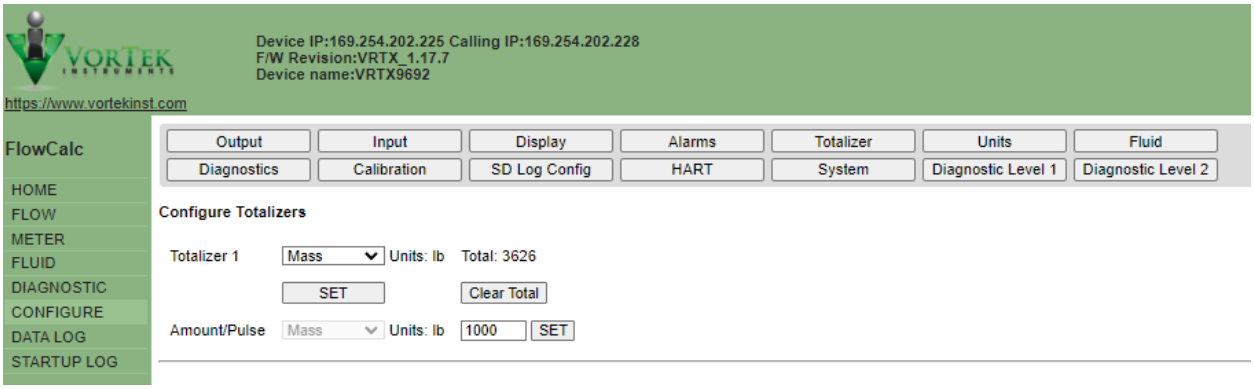


Figure 4.20 - Totalizer Tab

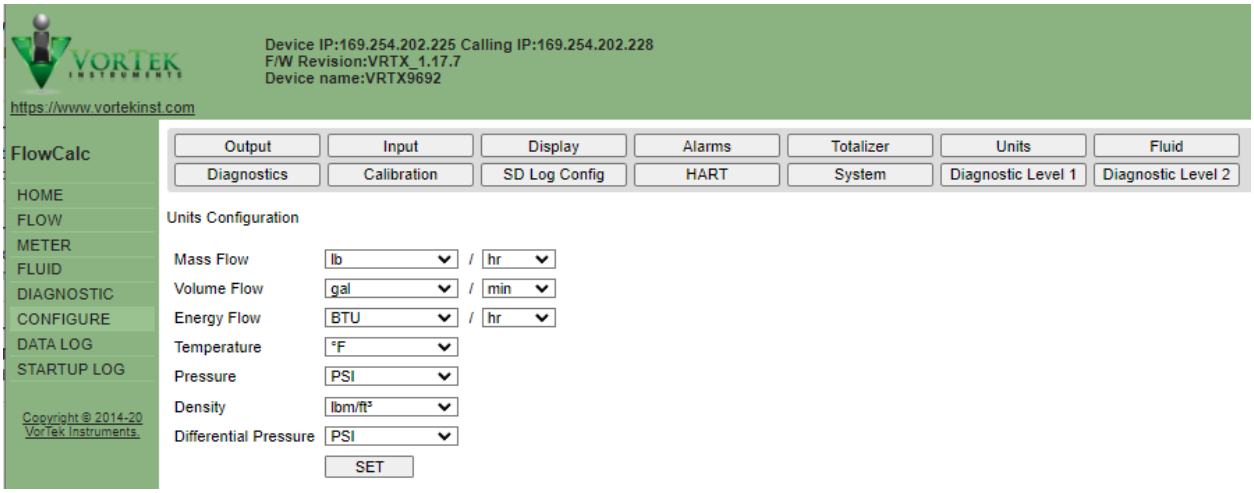


Figure 4.21 - Units Tab

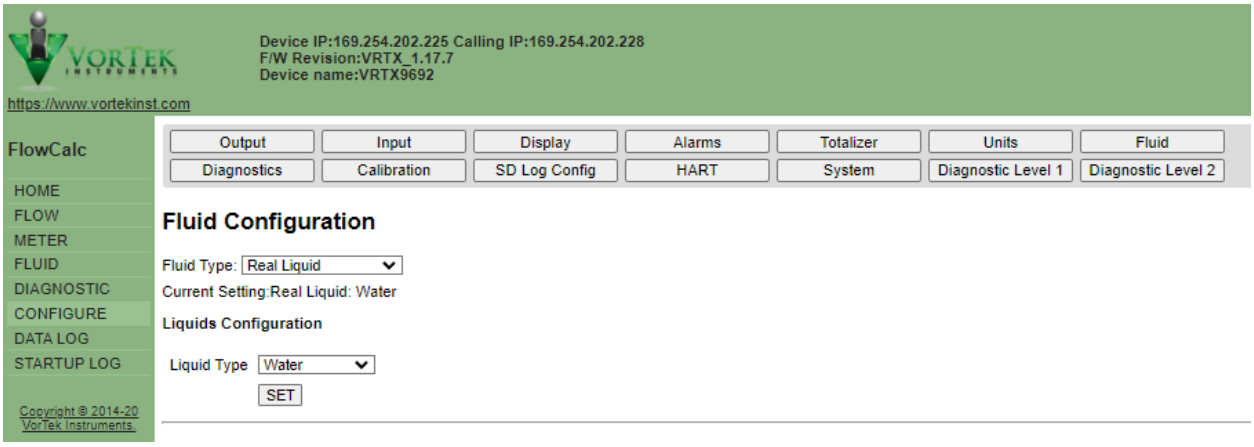


Figure 4.22 - Fluid Tab

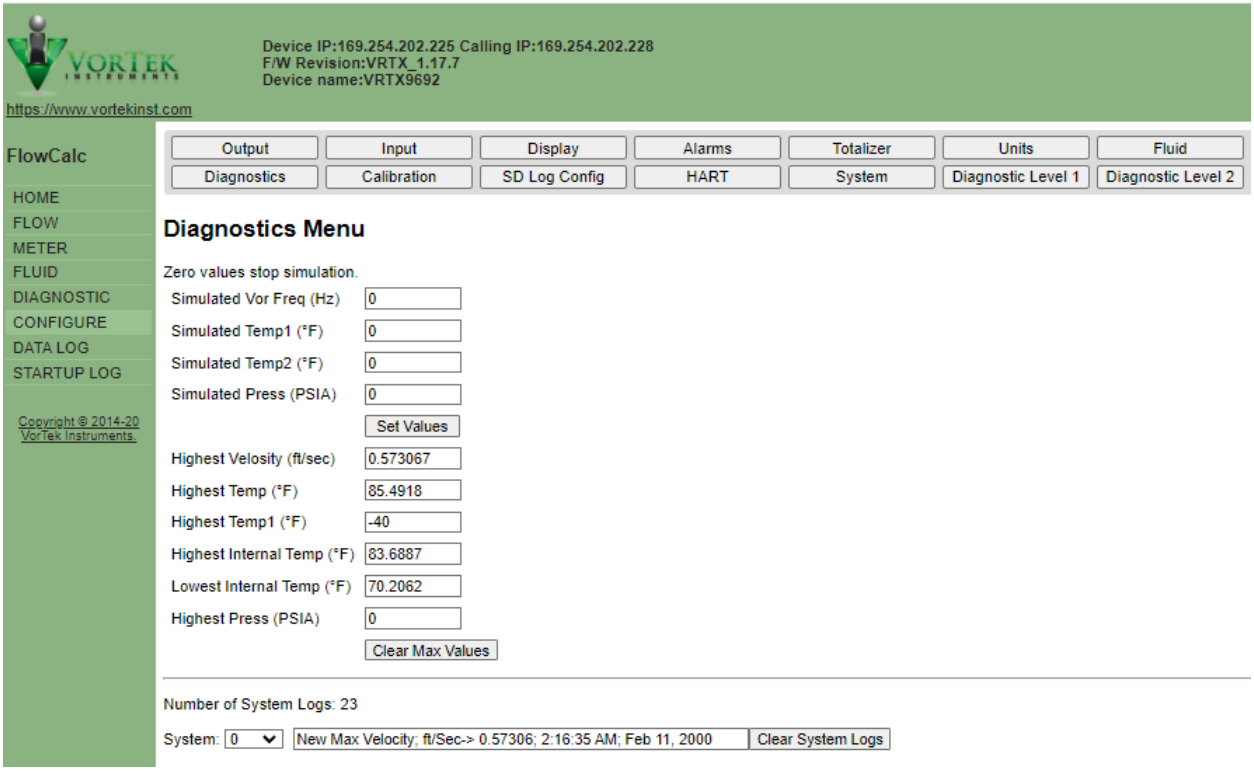


Figure 4.23 - Diagnostics Tab

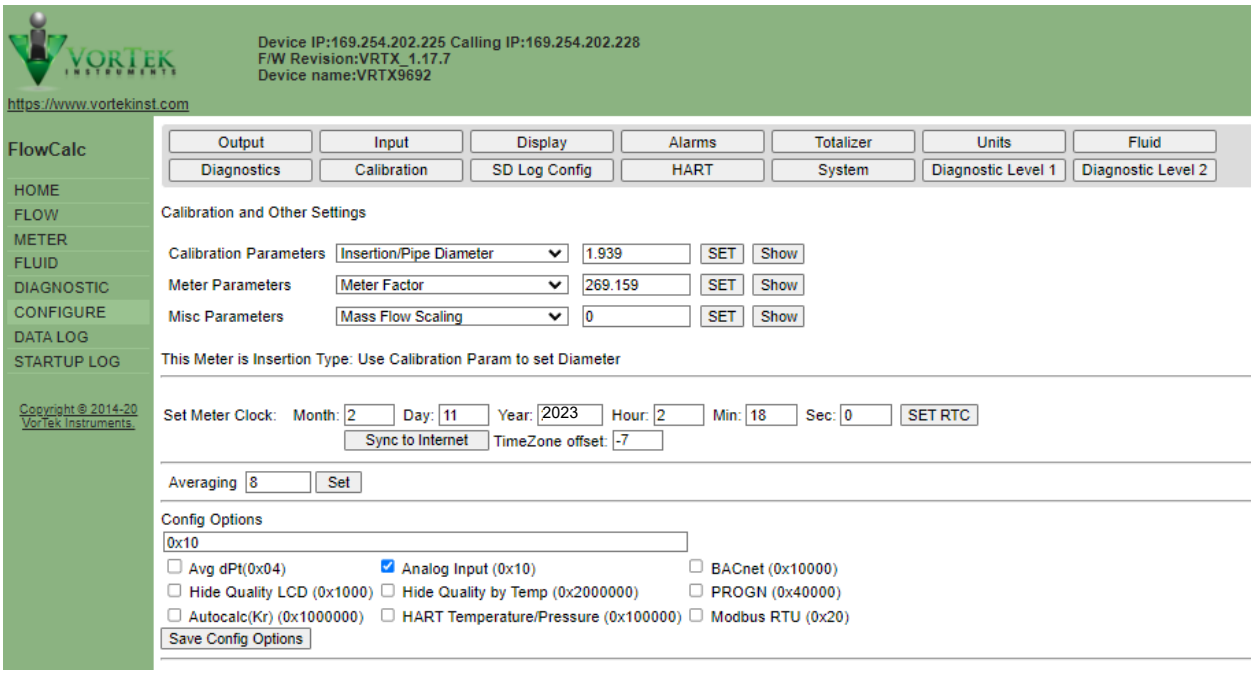


Figure 4.24 - Calibration Tab

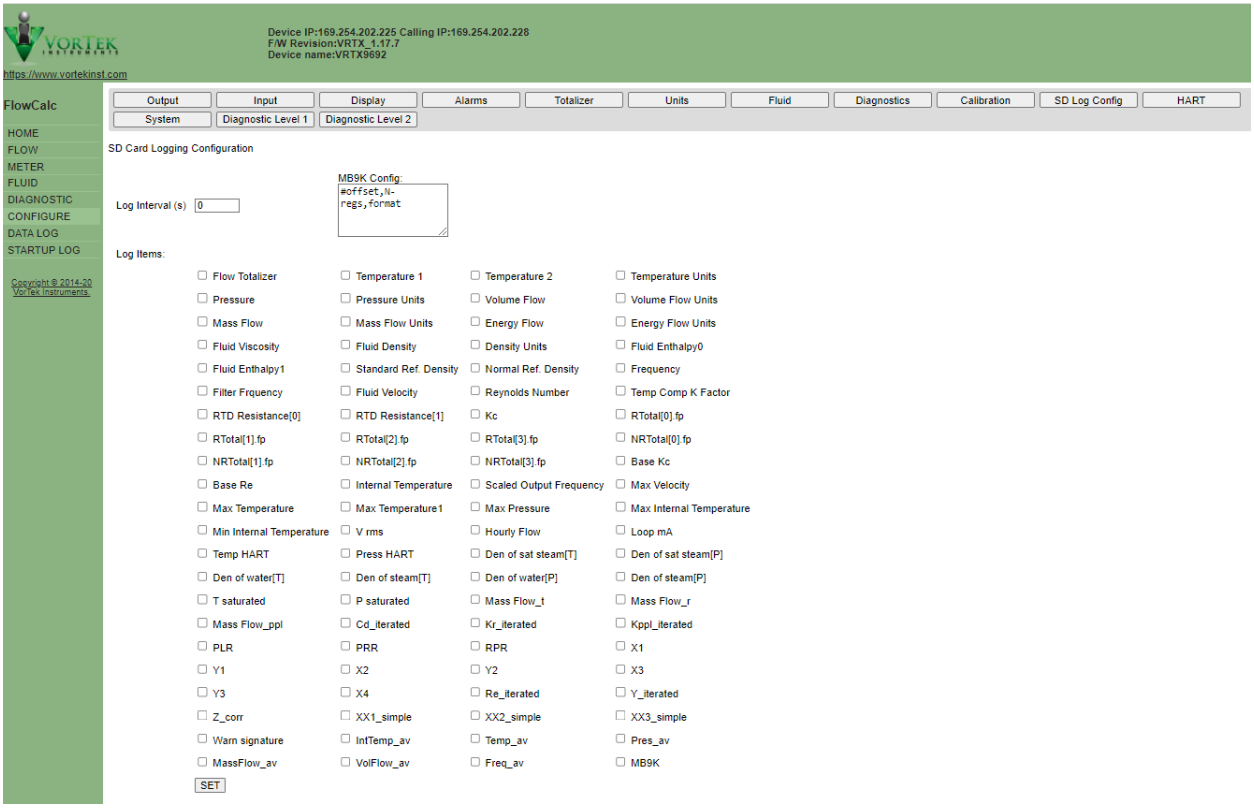


Figure 4.25 - SD Log Config. Tab

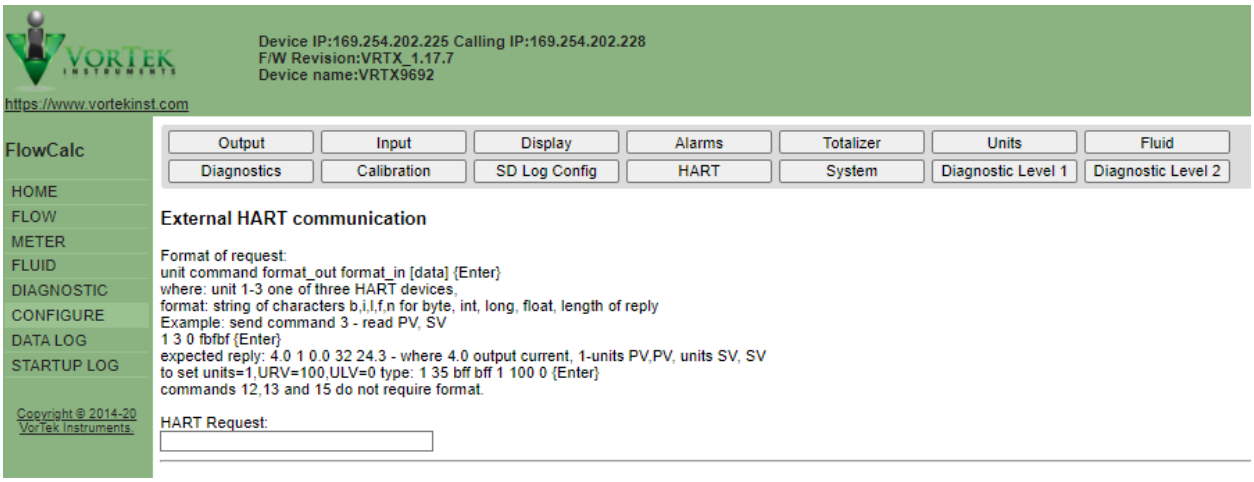


Figure 4.26 - HART Tab

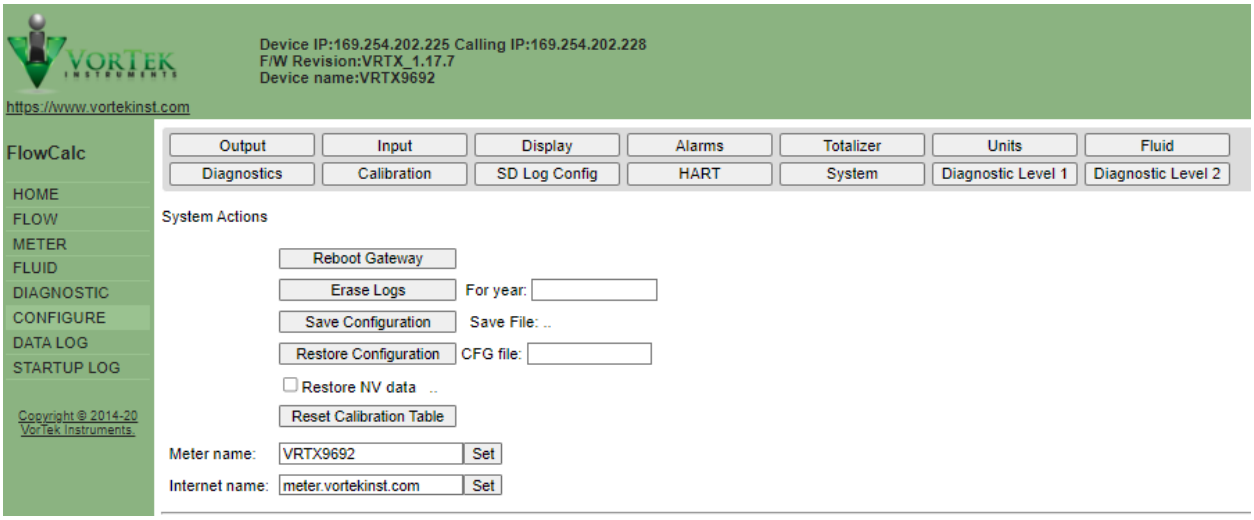


Figure 4.27 - System Tab

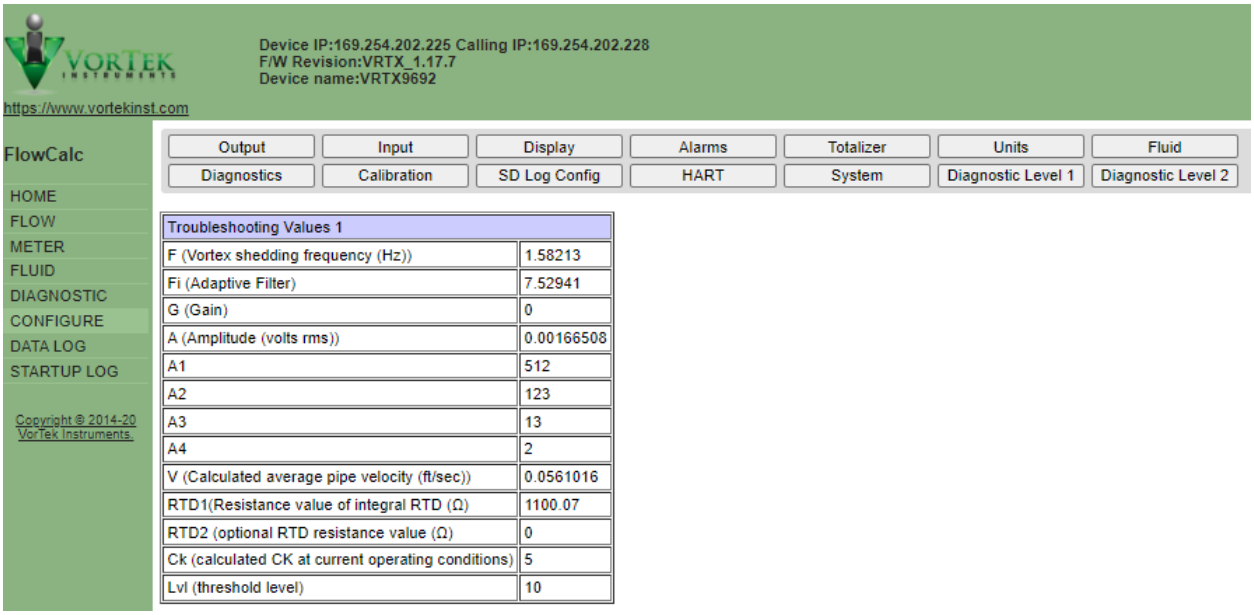


Figure 4.28 - Diagnostic Level 1 Troubleshooting Values 1 Tab

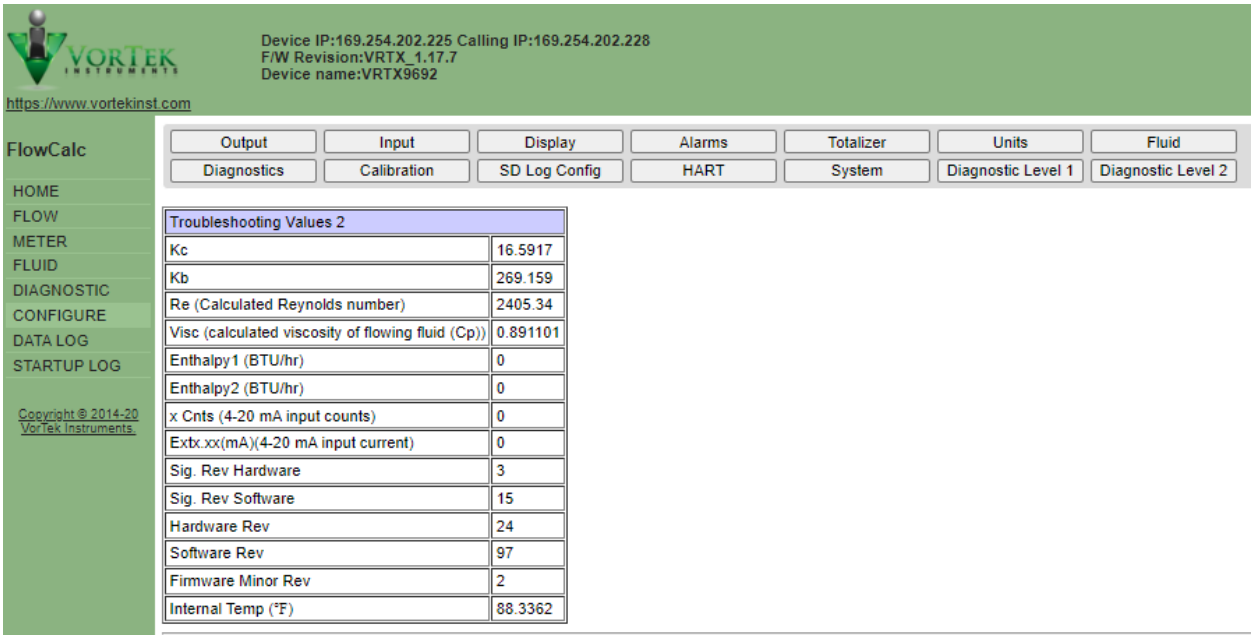


Figure 4.29 - Diagnostics Level 1 Troubleshooting Values 2 Tab

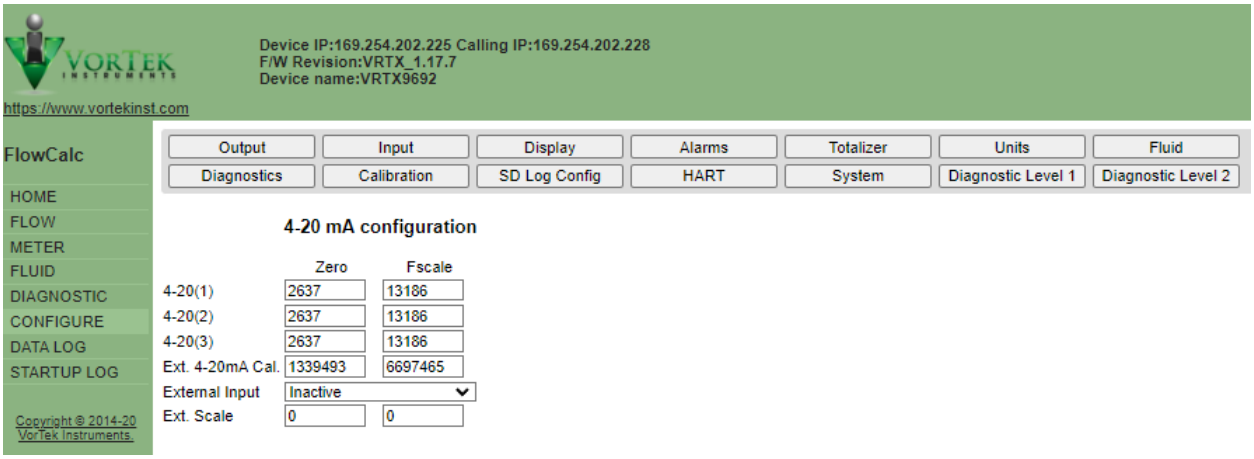


Figure 4.30 - Diagnostics Level 2 4-20 mA Configuration Tab

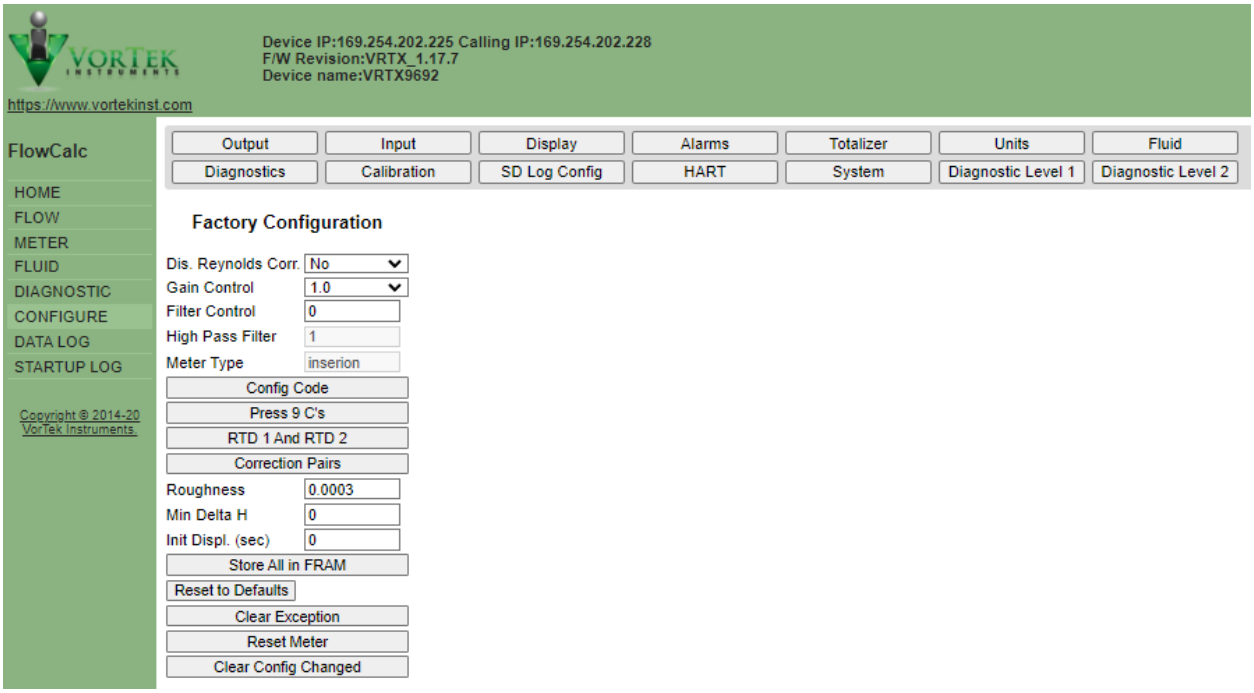


Figure 4.31 - Diagnostic Level 2 Factory Configuration Tab

Internet Connection to the Meter – Security Issues

Typically the meter is connected to the Local Area Network (LAN) with non-routable Private Network Address (192.168.xx.xx, 10.xx.xx.xx, 172.16-31.xx.xx). There are two options to setup the meter from the Internet:

- Connect via Virtual Private Network (VPN)
- Port Forwarding technique

In case of VPN, your home PC becomes part of your corporate network, which will allow access to all resources on the corporate LAN. Usually, your home PC is assigned an IP address from a different subnet than the meters. Therefore, the IPSetup program may not function correctly. You will need to know the specific IP address of the meter in order to connect. Please contact your IT department about availability of VPN and connection instructions.

Second method of Port Forwarding is configuring the corporate firewall to allow you access to certain internal (LAN) IP address by mapping it to your external corporate gateway IP and port number. This is usually done by mapping. See the following for an example. Assuming your corporate gateway is 50.202.79.132 and your meter IP on LAN is 10.10.10.75.

Example of Port Forwarding
External IP 50.202.79.132 Port 8080 → mapped to → 10.10.10.75 Port 80

External IP 50.202.79.132 Port 10502 → mapped to → 10.10.10.75 Port 502

External IP 50.202.79.132 Port 10443 → mapped to → 10.10.10.75 Port 443

Please contact your IT department for configuration on corporate routers. They will need the following information on the used network port:

TCP port 80

Non-secure access to main WEB pages. Read only. Protocol HTTP. It is also possible to access meter using only secure connection via Port 443.

TCP port 443

Secure encrypted access to configuration pages. Protocol HTTPS, SSL. Encryption 128 bit – does not require Export licensing.

User/password protected (secure)

TCP port 502

Access by automation software to Modbus/TCP server. Protocol Modbus/TCP

Optional: TCP ports 20,21- Access to internal FTP server. Protocol FTP. User/password protected (insecure)

UDP port 20034

Broadcast discover protocol. Used to find units on the local Network.

It is not routable and therefore works only within the same subnet.

Used by IPSetup (discover/IP config) and AutoUpdate (flash) programs. AutoUpdate works across Ethernet switches. It uses UDP with direct address. It may be blocked by most routers.

TCP port 20034

Firmware update using TcpUpdate utility. (Not enabled in Rev 1.0 of firmware).

Corporate gateways can have additional security enhancing measures, like sourcing. Sourcing addresses only allows access from certain individual IPs or networks. If security concerns are an issue, you may limit access to the meter using encrypted protocol only: port 443, https. On special request VortekInst can add special capability of Access Control List (ACL) to insecure by definition Modbus protocol. Using ACL user may define number of hosts or networks from which connection to Modbus port 502 can be accepted. Normally this function can be implemented in corporate firewall. ACL in meter may be needed when it is exposed to the Internet directly.

General information about Port Forwarding and instructions how to set up it in simple home routers available everywhere. E.g. here: http://www.howtogeek.com/66214/how-to-forward-ports-on-your- router/

Modbus/TCP Interface

VorTek's TCP meter supports industry standard automation protocol Modbus/TCP. Once connected to Modbus/TCP, the addresses will be the same as our standard options.

General specifications:

Protocol	TCP
Port	502
Number of Simultaneous Connections	20
Format of 16-bit Registers	Standard MSB first (big endian)
Format of 32 Long and Float Values	Most significant word coming first (big endian)
Modbus Address	0
Supported Function Codes	3, 4, 16, 5

Modbus Utilities

We include for customer convenience two applications which may be used during integration into your automation system:

- MbusGui.exe – Windows GUI application for reading Modbus registers of the meter.
- mbus.exe – Generic DOS console application for reading Modbus/TCP registers.

These two applications are stored on SD card inside the meter. To download them click on menu link "LOG DATA" and then select directory EXE. Right click on MBUS.EXE or MBGUI.EXE link to download it to your PC.

Figure 4.32 - EXE Folder

BACnet/TCP Interface

All meters are configured for Modbus communications when shipped. If you are communicating with BACnet TCP/IP, make sure "BACnet (0x10000)" is selected in the "Config Options" section of the Calibration tab and the setting are saved (see below). Cycle power to the meter once this setting is saved. Note, do not change settings on the physical meter. Once connected to BACnet/TCP, the objects will be the same as our standard options.

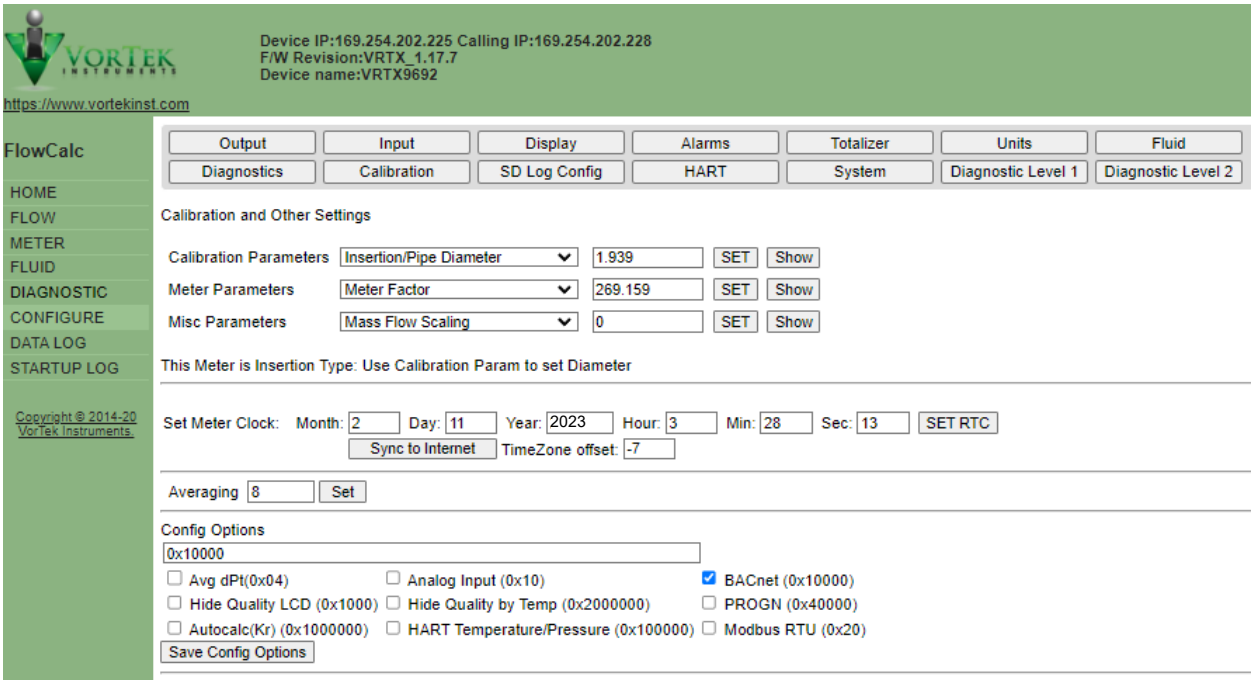


Figure 4.33 - Calibration Tab with BACnet Selected

Data Logging

VRTX/TCP meter has internal logging capability. The data is logged to micro SD card inside unit. The capacity of SD card may vary from 4 to 32 GB. The size of card and free space are shown on StartUp Log page. Card is formatted as FAT32 with long file name disabled. All file names are in 8.3 format. To access the log files, click menu link “DATA LOG”

Figure 4.34 - Data Log Menu

The following folders are in the Data Log Menu:

- LOGS Contains Log Files
- JOURNAL Log files of unit on/off states as well as operator’s actions
- EXE Folder with several executables
- DOCS Documentation

Log files are arranged as a tree: LOGS

2019 – Year

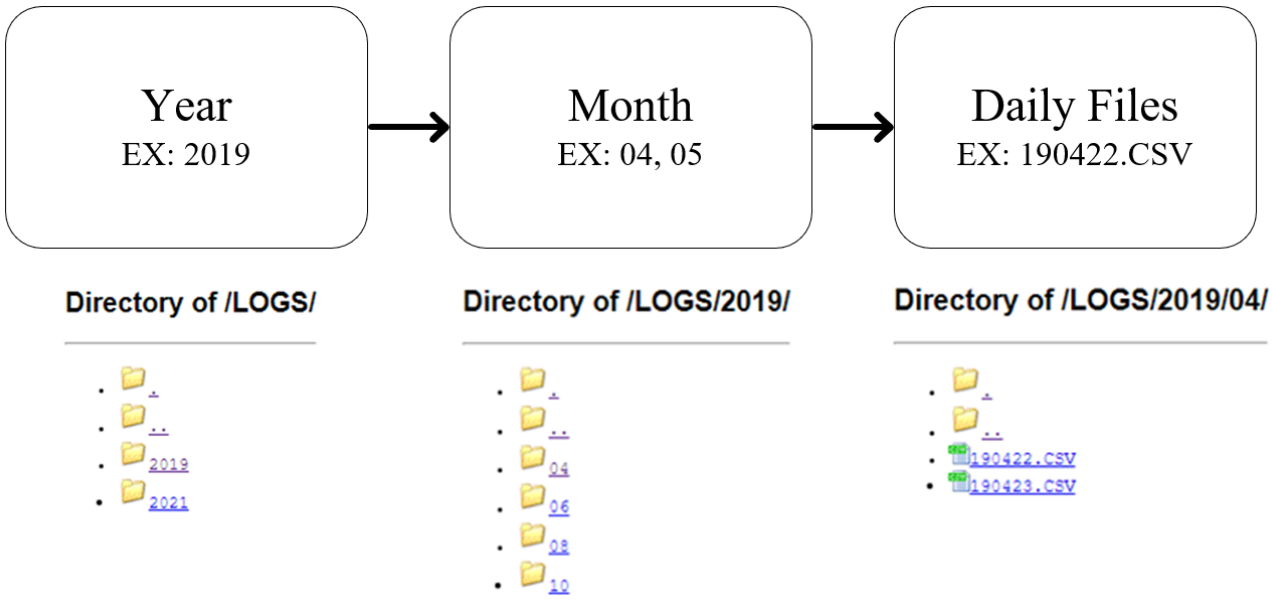
04 – Month

22 – Day

…

04 – April 190422.CSV

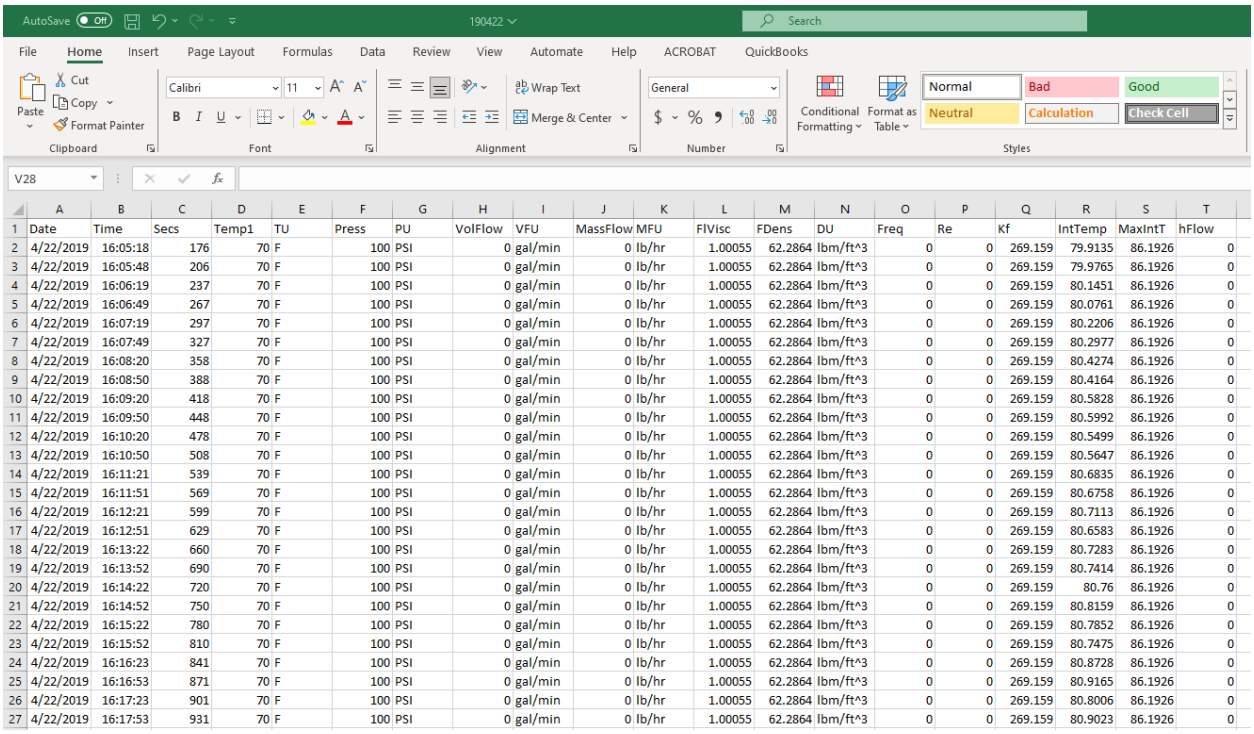
190422.CSV – Daily files in Comma Separated Values text format



To download file to your PC, right click on the file and select “save”. You may also open it immediately by clicking on the file. It will be opened as text file or in EXCEL depending on your settings of used browser. Consult HELP of used browser to find out how to configure a default application for file extension. Normally, your browser will ask what to do with this file extension (.CSV).

In each daily file log, the first three columns in table (A, B, and C) are fixed and always present. Column A is the date, Column B is the time, and Column C is the number of seconds since the meter was restarted. All other values are configurable on the SD Log Config tab on the CONFIGURE page.

The first row in the .CSV files will be the variable name. Columns named TU, PU, VFU, MFU, and DU display Temperature, Pressure, Volume Flow, Mass Flow, and Density Units accordingly. A new header will output whenever the operator changes the list of logged items. Log interval is set on the configure page and can vary from as low as 5 seconds to whatever you choose.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	Date	Time	Secs	Temp1	TU	Press	PU	VolFlow	VFU	MassFlow	MFU	FlVisc	FDens	DU	Freq	Re	Kf	IntTemp	MaxIntT	hFlow
2	4/22/2019	16:05:18	176	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	79.9135	86.1926	0
3	4/22/2019	16:05:48	206	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	79.9765	86.1926	0
4	4/22/2019	16:06:19	237	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	80.1451	86.1926	0
5	4/22/2019	16:06:49	267	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	80.0761	86.1926	0
6	4/22/2019	16:07:19	297	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	80.2206	86.1926	0
7	4/22/2019	16:07:49	327	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	80.2977	86.1926	0
8	4/22/2019	16:08:20	358	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	80.4274	86.1926	0
9	4/22/2019	16:08:50	388	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	80.4164	86.1926	0
10	4/22/2019	16:09:20	418	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	80.5828	86.1926	0
11	4/22/2019	16:09:50	448	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	80.5992	86.1926	0
12	4/22/2019	16:10:20	478	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	80.5499	86.1926	0
13	4/22/2019	16:10:50	508	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	80.5647	86.1926	0
14	4/22/2019	16:11:21	539	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	80.6835	86.1926	0
15	4/22/2019	16:11:51	569	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	80.6758	86.1926	0
16	4/22/2019	16:12:21	599	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	80.7113	86.1926	0
17	4/22/2019	16:12:51	629	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	80.6583	86.1926	0
18	4/22/2019	16:13:22	660	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	80.7283	86.1926	0
19	4/22/2019	16:13:52	690	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	80.7414	86.1926	0
20	4/22/2019	16:14:22	720	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	80.76	86.1926	0
21	4/22/2019	16:14:52	750	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	80.8159	86.1926	0
22	4/22/2019	16:15:22	780	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	80.7852	86.1926	0
23	4/22/2019	16:15:52	810	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	80.7475	86.1926	0
24	4/22/2019	16:16:23	841	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	80.8728	86.1926	0
25	4/22/2019	16:16:53	871	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	80.9165	86.1926	0
26	4/22/2019	16:17:23	901	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	80.8006	86.1926	0
27	4/22/2019	16:17:53	931	70	F	100	PSI	0	gal/min	0	lb/hr	1.00055	62.2864	lbm/ft^3	0	0	269.159	80.9023	86.1926	0

Figure 4.35 - EXCEL Example

The SD Log Config tab has the following variables available to log. Just select desired items and click SET button at the bottom of the page.

Figure 4.36 - SD Log Configuration Tab

Updating the Firmware

VORTEX meter firmware can be updated on-line. For that there are two applications:

- AutoUpdate – Standard update utility using UDP protocol. Local network only.
- TcpUpdate – Update utility using TCP protocol allowing access from other networks.

In revision 1.0 of VORTEX/TCP TcpUpdate is disabled. AutoUpdate should always be used.

The AutoUpdate application can be downloaded from EXE directory on SD file system of the unit.

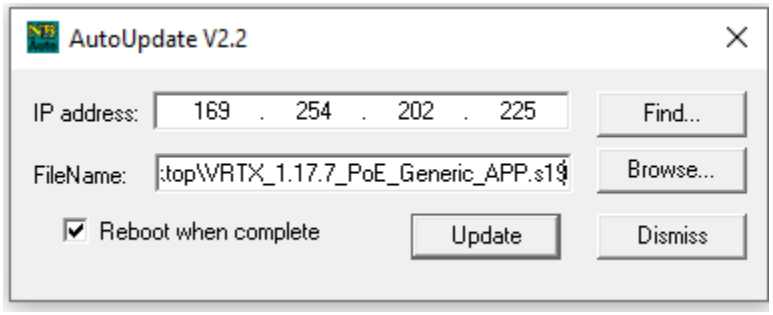


Figure 4.37 - AutoUpdate

Enter the IP address of your meter (or find meter on the local network). Browse for provided by VortekInst application file in xxx_APP.s19 format. Click update and then your firmware will be updated.

Update with TcpUpdate is the same, except FIND may not work across routers/switches.

Chapter 5 Troubleshooting and Repair

Hidden Diagnostics Menus

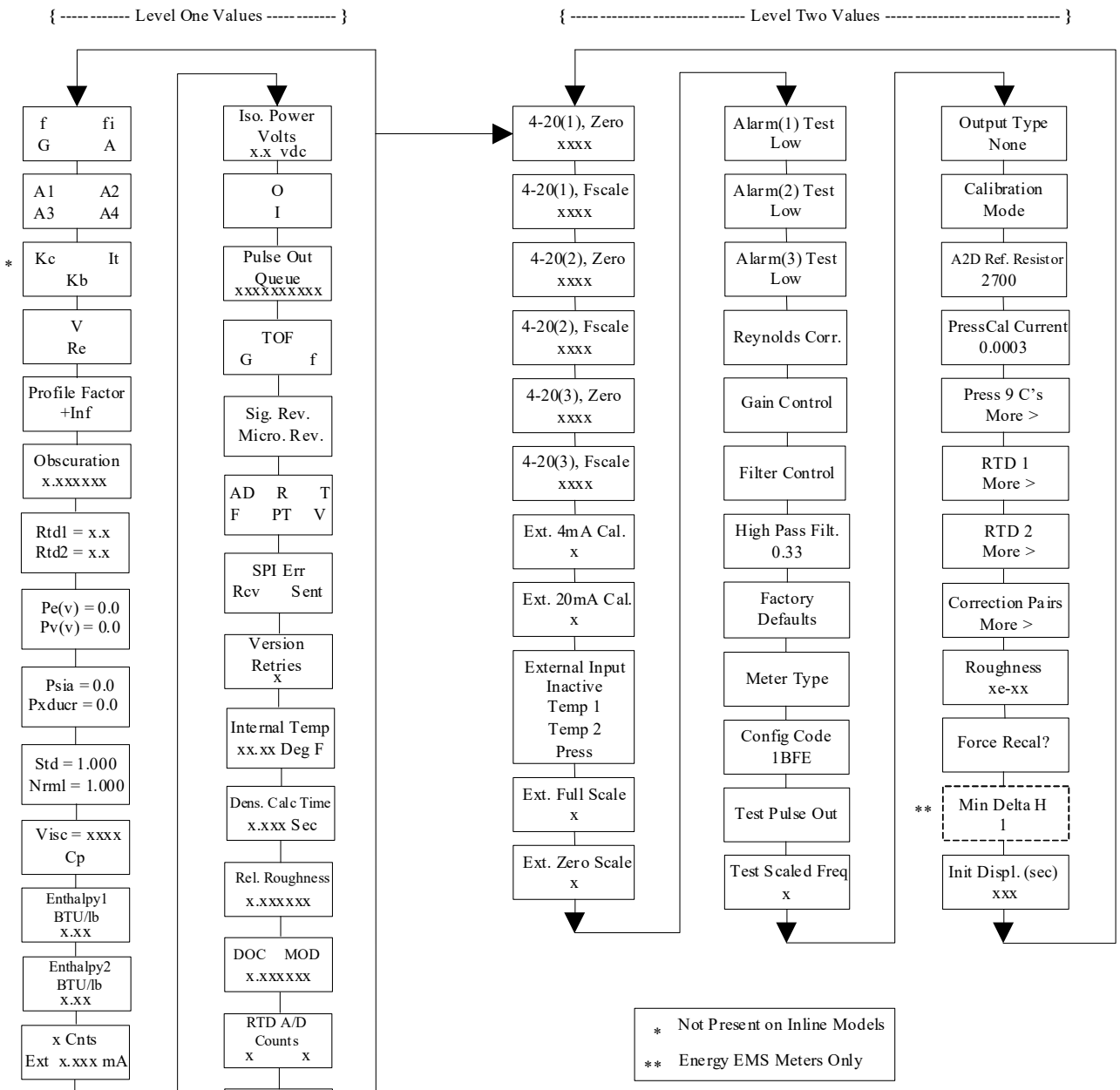
Warning!
Before attempting any flow meter repair, verify that the line is not pressurized. Always remove main power before disassembling any part of the mass flow meter.

The menus shown on the following page can be accessed using the password 16363, then moving to the display that reads “Diagnostics Menu” and pressing ENTER (rather than one of the arrow keys).

Use the right arrow key to move to the second level. Press EXIT to move from the second level back to the first, press EXIT while in the first level to return to the setup menus.

Caution: password 16363 will allow full access to the configuration and should be used carefully to avoid changes that can adversely alter the function of the meter.

Each of the menus on the following page will first be defined followed by specific trouble-shooting steps.


{ ---------- Level One Values ---------- }
{ ---------- Level Two Values ---------- }
f fi
G A
A1 A2
A3 A4
* Kc It
Kb
V
Re
Profile Factor
+Inf
Obscuration
x.xxxxxx
Rtd1 = x.x
Rtd2 = x.x
Pe(v) = 0.0
Pv(v) = 0.0
Psia = 0.0
Pxducr = 0.0
Std = 1.000
Nrml = 1.000
Visc = xxxx
Cp
Enthalpy1
BTU/lb
x.xx
Enthalpy2
BTU/lb
x.xx
x Cnts
Ext x.xxx mA
Ck
Lvl
Adj. Filter
xx dB
Iso. Power
Volts
x.x vdc
O
I
Pulse Out
Queue
xxxxxxxxx
TOF
G f
Sig. Rev.
Micro. Rev.
AD R T
F PT V
SPI Err
Rcv Sent
Version
Retries
x
Internal Temp
xx.xx Deg F
Dens. Calc Time
x.xxx Sec
Rel. Roughness
x.xxxxxx
DOC MOD
x.xxxxxx
RTD A/D
Counts
x x
Press A/D
Counts
x x
Temp. Corr. Kf
x.xx
4-20(1), Zero
xxxx
4-20(1), Fscale
xxxx
4-20(2), Zero
xxxx
4-20(2), Fscale
xxxx
4-20(3), Zero
xxxx
4-20(3), Fscale
xxxx
Ext. 4mA Cal.
x
Ext. 20mA Cal.
x
External Input
Inactive
Temp 1
Temp 2
Press
Ext. Full Scale
x
Ext. Zero Scale
x
Alarm(1) Test
Low
Alarm(2) Test
Low
Alarm(3) Test
Low
Reynolds Corr.
Gain Control
Filter Control
High Pass Filt.
0.33
Factory
Defaults
Meter Type
Config Code
1BFE
Test Pulse Out
Test Scaled Freq
x
Output Type
None
Calibration
Mode
A2D Ref. Resistor
2700
PressCal Current
0.0003
Press 9 C's
More >
RTD 1
More >
RTD 2
More >
Correction Pairs
More >
Roughness
xe-xx
Force Recal?
** Min Delta H
1
Init Displ. (sec)
xxx
* Not Present on Inline Models
** Energy EMS Meters Only

Level One Hidden Diagnostics Values

- **f** = Vortex shedding frequency (Hz).
- **fi** = Adaptive filter – should be approximately 25% higher than the vortex shedding frequency, this is a low-pass filter. If the meter is using the Filter Control (see below) in the manual mode, **fi** will be displayed as **fm**.
- **G** = Gain (applied to vortex signal amplitude). Gain defaults to 1.0 and can be changed using the Gain Control (see below).
- **A** = Amplitude of vortex signal in Volts rms.
- **A1, A2, A3, A4** = A/D counts representing the vortex signal amplitude. Each stage (A1-A4) cannot exceed 512. Beginning with stage A1, the A/D counts increase as the flow increases. When stage A1 reaches 512, it will shift to stage A2. This will continue as the flow rate increases until all 4 stages read 512 at high flow rates. Higher flow rates (stronger signal strength) will result in more stages reading 512.
- **Kc, It, Kb** = Profile equation (factory use only). Model M23 only.
- **V** = Calculated average pipe velocity (ft/sec).
- **Re** = Calculated Reynolds number.
- **Profile Factor** = Factory use only.
- **Obscuration** = Factory use only.
- **RTD1** = Resistance value of integral RTD in ohms.
- **RTD2** = Optional RTD resistance value in ohms.
- **Pe(v)** = Pressure transducer excitation voltage.
- **Pv(v) =** Pressure transducer sense voltage.
- **Psia =** Pressure value of integral transducer in psia.
- **Pxducr =** Pressure value of integral transducer in pressure unit.
- **Std** = Density of fluid at standard conditions.
- **Nrml =** Density of fluid at normal conditions.
- **Viscosity** = Calculated viscosity of flowing fluid.
- **Enthalpy1 BTU/lb** = Factory use only.
- **Enthalpy2 BTU/lb** = Factory use only.
- **x Cnts** = A/D counts from the external 4-20 mA input.
- **Ext x.xxx mA** = Calculated external 4-20 mA input from the digital counts.
- **Ck** = Calculated Ck at current operating conditions. Ck is a variable in the equation that relates signal strength, density, and velocity for a given application. It is used for noise rejection purposes. Ck directly controls the fi value (see above). If the Ck is set too low (in the calibration menu), then the fi value will be too low and the vortex signal will be rejected resulting in zero flow rate being displayed. The calculated Ck value in this menu can be compared to the actual Ck setting in the calibration menu to help determine if the Ck setting is correct.
- **Lvl** = Threshold level. If the Low Flow Cutoff in the calibration menu is set above this value, the meter will read zero flow. The Lvl level can be checked at no flow. At no flow, the Lvl must be below the Low Flow Cutoff setting or the meter will have an output at no flow.

- **Adj. Filter** = Adjustable filter. Displays the filtering in decibels. Normally reads zero. If this value is consistently -5 or -10, for example, the Ck or density setting may be wrong.
- **Iso. Power Volts** = Nominally 2.7 VDC, if less than this check the flow meter input power.
- **O, I** = Factory use only.
- **Pulse Out Queue** = Pulse output queue. This value will accumulate if the totalizer (unit)/pulse is set too low. Pulses will accumulate faster than the pulse output hardware can function. The queue will allow the pulses to "catch up" later if the flow rate decreases, causing stored pulses to output not in real time. A better practice is to slow down the totalizer pulse by increasing the value in the (unit)/pulse setting in the totalizer menu.
- **TOF, G, f** = Factory use only.
- **Sig. Rev** = Signal board hardware and firmware revision.
- **Miro Rev** = Microprocessor board hardware and firmware revision.
- **AD, R, T, F, PT, V** = Factory use only.
- **SPI Err, Rcv, Sent** = Factory use only.
- **Version Retries =** Factory use only.
- **Internal Temperature =** Electronics temperature.
- **Dens. Calc Time =** Factory use only.
- **Rel. Roughness =** Factory use only.
- **DOC, MOD =** Factory use only.
- **RTD A/D Counts =** Factory use only.
- **Press A/D Counts =** Factory use only.
- **Temp. Corr. Kf =** Factory use only.

Level Two Hidden Diagnostics Values

- **4-20(1) Zero** = Analog counts to calibrate zero on analog output 1.
- **4-20(1) FScale** = Analog counts to cal. full scale on analog output 1.
- **4-20(2) Zero** = Analog counts to calibrate zero on analog output 2.
- **4-20(2) FScale** = Analog counts to cal. full scale on analog output 2.
- **4-20(3) Zero** = Analog counts to calibrate zero on analog output 3.
- **4-20(3) FScale** = Analog counts to cal. full scale on analog output 3.
- **Ext. 4 mA Cal.** = Enter 0 for auto calibration or enter factory supplied A/D counts. Note: You must connect a known 4.00 mA input if you are going to calibrate the unit.
- **Ext. 20 mA Cal.** = Enter 0 for auto calibration or enter factory supplied A/D counts. Note: You must connect a known 20.00 mA input if you are going to calibrate the unit.
- **External Input** = Enter what the external 4-20 mA input represents, i.e. Temperature 1, Temperature 2, or Pressure. The meter will use this for its internal calculations.
- **Ext. Full Scale** = Enter the full scale units that correlate to the 20 mA point. Note: It must be in the units for the selected input type such as Deg F, Deg C, PSIA, Bar A, etc.
- **Ext. Zero Scale** = Same as above but for the 4 mA point.

- **Alarm (1) Test** = Used as a test to verify that the alarm circuit is functioning. When low is selected the alarm will initiate a low alarm on the output. When High is selected it will give a high alarm on the output.
- **Alarm (2) Test** = Used as a test to verify that the alarm circuit is functioning. When low is selected the alarm will initiate a low alarm on the output. When High is selected it will give a high alarm on the output.
- **Alarm (3) Test** = Used as a test to verify that the alarm circuit is functioning. When low is selected the alarm will initiate a low alarm on the output. When High is selected it will give a high alarm on the output.
- **Reynolds Corr.** = Reynolds number correction for the flow profile. Set to Enable for M23 insertion and set to Disable for M22/M24 inline.
- **Gain Control** = Manual gain control (factory use only). Leave set at 1.
- **Filter control** = Manual filter control. This value can be changed to any number to force the fi value to a constant. A value of zero activates the automatic filter control which sets fi at a level that floats above the f value.
- **High Pass Filter =** Filter setting – Factory use only
- **Factory Defaults** = Reset factory defaults. If you change this to Factory and press Enter, all the factory configuration is lost and you must reconfigure the entire program. Consult the factory before performing this process, it is required only in very rare cases.
- **Meter Type** = Insertion (M23) or Inline (M22/M24) meter.
- **Config Code =** Factory use only.
- **Test Pulse Out** = Force totalizer pulse. Set to Yes and press enter to send one pulse. Very useful to test totalizer counting equipment.
- **Test Scaled Freq** = Enter a frequency value in order to test the scaled frequency output. Return to 0 to stop the test.
- **Output Type** = Factory use only.
- **Calibration Mode** = Factory use only.
- **A2D Ref. Resistor =** Factory use only.
- **Pressure Cal Current** = Calibration value for the electronics and pressure transducer combination. Consult Factory for value.
- **Pressure 9 C's** = Nine pressure coefficients unique to the pressure transducer. Use the RIGHT ARROW to access all nine coefficients.
    - **Press. Max psi** = Based on installed sensor.
    - **Press. Min psi =** 0 psia
- **RTD1 =** Press the RIGHT ARROW to access:
    - **Ro** = RTD resistance at 0°C (1000 ohms).
    - **A** = RTD coefficient A (.0039083).
    - **B** = RTD coefficient B (-5.775e-07).
    - **RTD1 Max Deg. F =** 500
    - **RTD1 Min Deg. F =** -330
- **RTD2** = Second RTD configuration, for special applications only.
- **Correction Pairs**

  - **ft3/sec** (1 through 10)
  - **%Dev.** (1 through 10)
- **Roughness** = Factory use only.
- **Force Recal?** = Factory use only.
- **Min. Delta H –** Energy EMS meters only. Sets the deadband for totalization to begin. Must be greater than this number (1 default) to initiate the totalizer.

  Init Displ. (sec) = Enter a value in seconds to initialize the display every xxx seconds. Enter a value of 0 to disable initializing the display.

Analog Output Calibration

To check the 4–20 mA circuit, connect a DVM in series with the output loop. Select zero or full scale (from the second level of the hidden diagnostics) and then actuate the enter key twice. This action will cause the meter to output its 4 mA or 20 mA condition. If the DVM indicates a current greater than ± 0.006 mA from 4 or 20, adjust the setting up or down until the output is calibrated.

Note: these settings are not for adjusting the output zero and span to match a flow range, that function is located in the Output Menu.

Display Contrast Adjustment

The flow meter display contrast is set at the factory but if the display characters appear too dark or too light proceed as follows:

1. Hold down the “Exit” button on the front panel for 5 to 10 seconds. “Setting Contrast” will appear.
2. Push the “Up” arrow to darken the display or the “Down” arrow to lighten it.
3. Push the “Enter” button to save the contrast setting.

Appendix A Product Specifications

Power Requirements	12 to 36 VDC, 25 mA, 1 W max., Loop Powered Volumetric or Mass 12 to 36 VDC, 300 mA, 9 W max. Multiparameter Mass options 100 to 240 VAC, 50/60 Hz, 5 W max. Multiparameter Mass options Use a Class 2 isolated power supply that is grounded, provides DC output, and has no more than 10% output ripple. Installation (Over-voltage) Category II for transient over-voltages AC & DC Mains supply voltage fluctuations are not to exceed +/-10% of the rated supply voltage range. User is responsible for the provision of an external disconnect means, disconnect line 1 and line 2 when 220 / 240 VAC power is used, also provide over-current protection for the equipment (both AC and DC models).
Display	Alphanumeric 2 x 16 LCD digital display. Six push-button switches (up, down, right, left, enter, exit) operable through explosion-proof window using hand-held magnet. Viewing at 90-degree mounting intervals.
Ambient Temperature	Ambient: Operating temperature range: –40 to 140° F (–40 to 60° C) Storage temperature range: –40 to 185° F (–40 to 85° C) Maximum relative humidity: 0-98%, non-condensing conditions Maximum altitude: -2000 to 14,000 feet (-610 to 4268 meters) Pollution Degree 2 for the ambient environment
Output Signals (1)	Analog: Volumetric Meter: field rangeable linear 4-20 mA output signal (1200 Ohms maximum loop resistance) selected by user for mass flow rate or volumetric flow rate. Communications: HART, MODBUS, RS485, BACnet, POE

	Multiparameter Meter: up to three field rangeable linear 4-20 mA output signals (1200 Ohms maximum loop resistance) selected from the five parameters–mass flow rate, volumetric flow rate, temperature, pressure and density.
	Pulse: Pulse output for totalization is a 50-millisecond duration pulse operating a solid-state relay capable of switching 40 VDC, 40 mA maximum.
	Note: (1) All outputs are optically isolated and require external power for operation.
Alarms	Up to three programmable solid-state relays for high, low or window alarms capable of switching 40 VDC, 40 mA maximum.
Totalizer	Based on user-determined flow units, six significant figures in scientific notation. Total stored in non-volatile memory.
Enclosure Protection Classification	NEMA 4X and IP66 cast enclosure.
Electrical Ports	Two 3/4-inch female NPT ports.
Certifications	Material Certificate – US Mill certs on all wetted parts
	Pressure Test Certificate
	Certificate of Conformance
	NACE Certification (MR0175)
	Oxygen Cleaning (CGA G-4.
Approvals	FM / FMC, ATEX, IECEX

Model Number Information - FlowCalc™ Flow Computer

Parent Number Code	**FC**	Flow Computer

Feature 1: Multivariable Options

VEI	External Flow Input
VEIET	External Flow Input and External RTD Temperature Input
VEIETEM	External Flow Input, External RTD Temperature Input, External RTD Temperature Input

Feature 2: Input Power

DCH	12-36 VDC, 300mA, 9W max. – use with 1AH, 1AM, 3AH, 3AM	
DCHPOE	12-28 VDC or Power over Ethernet, 5 Watts maximum, required on 1AMIP, 1ABIP, 3AMIP, 3ABIP	*Adds additional input options
AC	100-240 VAC, 50/60 Hz line power, 5W max. – use with 1AH, 1AM, 3AH, 3AM	

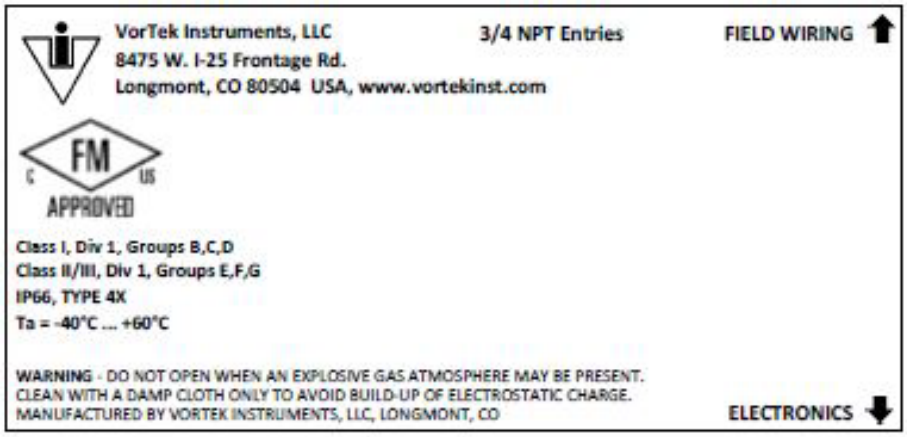
Feature 3: Output

1AH	One analog output (4-20 mA), one alarm, one pulse, HART Communication Protocol, DCH or AC option only *	
1AM	One analog output (4-20 mA), one alarm, one pulse, MODBUS RTU Communication Protocol, DCH or AC option only *	
1AMIP	One analog output (4-20 mA), one alarm, one pulse, MODBUS TCP/IP Communication Protocol, DCHPOE ONLY*	
1AB	One analog output (4-20 mA), one alarm, one pulse, BACnet MS/TP Communication Protocol, DCH or AC option only *	
1ABIP	One analog output (4-20 mA), one alarm, one pulse, BACnet/IP Communication Protocol, DCHPOE ONLY *	
3AH	Three analog outputs (4-20 mA), three alarms, one pulse, HART (VT,VTP only), DCH or AC option only *	
3AM	Three analog outputs (4-20 mA), three alarms, one pulse, MODBUS RTU (VT,VTP only), DCH or AC option only *	
3AMIP	Three analog outputs (4-20 mA), three alarms, one pulse, MODBUS TCP/IP (VT,VTP only), DCHPOE ONLY*	
3AB	Three analog outputs (4-20 mA), three alarms, one pulse, BACnet MS/TP (VT,VTP only), DCH or AC option only *	
3ABIP	Three analog outputs (4-20 mA), three alarms, one pulse, BACnet/IP (VT,VTP only), DCHPOE ONLY *	*Includes scaled frequency output

Feature 4: DP Diagnostics	**DP**	DP Diagnostics Available	*Must select DCHPOE option

Appendix B Approvals

FlowCalc Label



Technical assistance may be obtained by contacting Customer Service at:
(888) 386-7835 or (303) 682-9999 in the USA

Appendix C Flow Computer Calculations

In-Line Flow Meter Calculations

Volume Flow Rate

$$Q_V = \frac{f}{K}$$

Flowing Velocity

$$V_f = \frac{Q_V}{A}$$

Mass Flow Rate

$$Q_M = Q_V \rho$$

Where:

A = Cross sectional area of the pipe (ft^2)
f = Vortex shedding frequency (pulses / sec)
K = Meter factor corrected for thermal expansion (pulses / ft^3)
Q_M = Mass flow rate (lbm / sec)
Q_v = Volume flow rate (ft^3 / sec)
V_f = Flowing velocity (ft / sec)
ρ = Density (lbm / ft^3)

Insertion Flow Meter Calculations

Flowing Velocity

$$V_f = \frac{f}{K_c}$$

Volume Flow Rate

$$Q_V = V_f A$$

Mass Flow Rate

$$Q_M = V_f A \rho$$

Where:

A = Cross sectional area of the pipe (ft^2)
f = Vortex shedding frequency (pulses / sec)
K_c = Meter factor corrected for Reynolds Number (pulses / ft)
Q_v = Volume flow rate (ft^3 / sec)
Q_M = Mass flow rate (lbm / sec)
V_f = Flowing velocity (ft / sec)
ρ = Density (lbm / ft^3)

Energy Flow Calculations

Energy is calculated for a steam supply/condensate return or hot/chilled water system. For steam/water, the meter must be located in the supply line; otherwise, the meter may be located in either the supply line or in the return line.

Steam supply, water return, meter steam supply
Energy = mdot * (h0 - pctRet * h1)

Where:
mdot = mass flow at the meter, lbm/sec
pctRet = estimated percent of mass flow returned
h0 = Steam Enthalpy (t0, p)
h1 = Water Enthalpy (t1)
t0 = steam temperature
t1 = return water temperature
p = steam pressure

Water supply and return, meter supply
Energy = mdot * (h0 - pctRet * h1)

Where:
h0 = Water Enthalpy (t0)
h1 = Water Enthalpy (t1)
t0 = supply water temperature
t1 = return water temperature

Water supply and return, meter return
Energy = mdot * (h1/pctRet - h0)

Where:
h0 = Water Enthalpy (t0)
h1 = Water Enthalpy (t1)
t0 = return water temperature
t1 = supply water temperature

The energy flow is positive if less energy is returned than is supplied. This implies that chilled water systems will indicate negative energy flow. Positive and negative energy flows are accumulated in separate totalizers.

Fluid Calculations

Calculations for Steam T & P

When "Steam T & P" is selected in the "Real Gas" selection of the Fluid Menu, the calculations are based on the equations below.

Density

The density of steam is calculated from the formula given by Keenan and Keys. The given equation is for the specific volume of the steam.

$$v = \frac{4.55504\ (T)}{p} + B$$

$$B = B_0 + B_0{}^2 g_1(\tau)\tau \cdot p + B_0{}^4 g_2(\tau)\tau^3 \cdot p^3 - B_0{}^{13} g_3(\tau)\tau^{12} \cdot p^{12}$$

$$B_0 = 1.89 - 2641.62 \cdot \tau \cdot 10^{80870\tau^2}$$

$$g_1(\tau) = 82.546 \cdot \tau \ -1.6246 \cdot 10^5 \cdot \tau^2$$

$$g_2(\tau) = 0.21828 - 1.2697 \cdot 10^5 \cdot \tau^2$$

$$g_3(\tau) = 3.635 \cdot 10^{-4} - 6.768 \cdot 10^{64} \cdot \tau^{24}$$

Where tau is 1/ temperature in Kelvin.

The density can be found from $1/v$ (specific volume of steam).

Viscosity

The viscosity is based on an equation given by Keenan and Keys.

$$\eta(poise) = \frac{1.501 \cdot 10^{-5}\sqrt{T}}{1 + 446.8/T}$$

Where T is the temperature in Kelvin

Calculations for Gas ("Real Gas" and "Other Gas")

Use this formula to determine the settings for "Real Gas; Gas" selections and "Other Gas" selections entered in the Fluid Menu. The calculations for gas were taken from Richard W. Miller, *Flow Measurement Engineering Handbook (Third Edition, 1996)*.

Density

The density for real gases is calculated from the equation:

$$\rho = \frac{GM_{w,Air}p_f}{Z_f R_0 T_f}$$

Where G is the specific gravity, M_W is the molecular weight of air, p_f is the flowing pressure, Z is flowing compressibility, Ro is the universal gas constant, and T is the flowing temperature.

The specific gravity, and Ro are known and are stored in a table used by the Vortex meter.

The hard coefficient to find is the compressibility, Z. Z is found using the Redlich-Kwong Equation (Miller page 2-18).

The Redlich-Kwong Equation uses the reduced temperature and pressure to calculate the compressibility factor. The equations are non linear and an iterative solution is used. The Vortex program uses Newton's Method on the Redlich-Kwong equations to iteratively find the compressibility factor. The critical temperature and pressure used in the Redlich-Kwong equation are stored in the fluid data table with the other coefficients.

Viscosity

The viscosity for real gases is calculated using the exponential equation for two known viscosities. The equation is:

$$\mu_{cP} = aT_K^n$$

Where a and n are found from two known viscosities at two temperatures.

$$n = \frac{\ln[(\mu_{cP})_2/(\mu_{cP})_1]}{\ln(T_{K2}/T_{K1})}$$

and

$$a = \frac{(\mu_{cP})_1}{T_{K1}^n}$$

Calculations for Liquid

Use this formula to determine the settings for “Goyal-Dorais” selections and “Other Liquid” selections entered in the Fluid Menu. The liquid calculations were taken from Richard W. Miller, *Flow Measurement Engineering Handbook (Third Edition, 1996)*.

Density

The liquid density is found using the Goyal-Doraiswamy Equation. Goyal-Doraiswamy uses the critical compressibility, critical pressure and critical temperature, along with the molecular weight to find the density. The equation for specific gravity is:

$$G_F = \frac{p_c Mw}{T_c}\left(\frac{0.008}{Z_c^{0.773}} - 0.01102\frac{T_f}{T_C}\right)$$

The specific gravity can then be converted into density.

Viscosity

The liquid viscosity is found by Andrade's equation. This uses two viscosities at different temperatures to extrapolate the viscosity.

Andrade's equation:

$$\mu = A_L \exp\frac{B_L}{T_{\deg R}}$$

To find A and B

$$B_L = \frac{T_{\deg R1} T_{\deg R2} \ln(\mu_1 / \mu_2)}{T_{\deg R2} - T_{\deg R1}}$$

$$A_L = \frac{\mu_1}{\exp(B_L / T_{\deg R1})}$$

The temperatures are all in degrees Rankin. Do not believe the subscript R means they are reduced temperatures.

Appendix D Glossary

A B C D

A	Cross sectional area.
ACFM	Actual Cubic Feet Per Minute (volumetric flow rate).
ASME	American Society of Mechanical Engineers.
Bluff Body	A non-streamlined body placed into a flow stream to create vortices. Also called a Shedder Bar.
BTU	British Thermal Unit, an energy measurement.
Cenelec	European Electrical Code.
Compressibility Factor	A factor used to correct for the non-ideal changes in a fluid's density due to changes in temperature and/or pressure.
CSA	Canadian Standards Association.
d	Width of a bluff body or shedder bar.
D	Diameter of a flow channel.

E F G H

f	Frequency of vortices generated in a vortex flow meter, usually in Hz.
Flow Channel	A pipe, duct, stack, or channel containing flowing fluid.
Flow Profile	A map of the fluid velocity vector (usually non-uniform) in a cross-sectional plane of a flow channel (usually along a diameter).
FM	Factory Mutual.
Ft	Foot, 12 inches, a measure of length.
Ft^2	Square feet, measure of area.
Ft^3	Cubic feet, measure of volume.
GPM	Gallons Per Minute.
Hz	Hertz, cycles per second.

I J K L

In-Line Flow Meter	A flow meter which includes a short section of piping which is put in-line with the user's piping.
Insertion Flow Meter	A flow meter which is inserted into a hole in the user's pipeline.
Joule	A unit of energy equal to one watt for one second. Also equal to a Newton-meter.
LCD	Liquid crystal display.

M N O P

$\dot{m}$	Mass flow rate.
mA	Milli-amp, one thousandth of an ampere of current.
μ	Viscosity, a measure of a fluid's resistance to shear stress. Honey has high viscosity, alcohol has low viscosity.
nm3/hr	Normal cubic meters per hour (flow rate converted to normal conditions, as shipped 101 kPa and 0° C). User definable.
ΔP	Permanent pressure loss.
P	Line pressure (psia or bar absolute).
ρ_{act}	The density of a fluid at the actual temperature and pressure operating conditions.
ρ_{std}	The density of a fluid at standard conditions (usually 14.7 psia and 20° C).
Permanent Pressure Loss	Unrecoverable drop in pressure.
Piezoelectric Crystal	A material which generates an electrical charge when the material is put under stress.
PRTD	An resistance temperature detector (RTD) with platinum as its element. Used because of high stability.
psia	Pounds per square inch absolute (equals psig + atmospheric pressure). Atmospheric pressure is typically 14.696 psi at sea level.
psig	Pounds per square inch gauge.
P_V	Liquid vapor pressure at flowing conditions (psia or bar absolute).

Q R S T

Q	Flow rate, usually volumetric.
Rangeability	Highest measurable flow rate divided by the lowest measurable flow rate.
Reynolds Number or Re	A dimensionless number equal to the density of a fluid times the velocity of the fluid times the diameter of the fluid channel, divided by the fluid viscosity (i.e., $Re = \rho VD/\mu$). The Reynolds number is an important number for vortex flow meters because it is used to determine the minimum measurable flow rate. It is the ratio of the inertial forces to the viscous forces in a flowing fluid.
RTD	Resistance temperature detector, a sensor whose resistance increases as the temperature rises.
scfm	Standard cubic feet per minute (flow rate converted to standard conditions, as shipped 14.696 psia and 59° F). User definable.
Shedder Bar	A non-streamlined body placed into a flow stream to create vortices. Also called a Bluff Body.
Strouhal Number or St	A dimensionless number equal to the frequency of vortices created by a bluff body times the width of the bluff body divided by the velocity of the flowing fluid (i.e., $St = fd/V$). This is an important number for vortex flow meters because it relates the vortex frequency to the fluid velocity.
Totalizer	An electronic counter which records the total accumulated flow over a certain range of time.
Traverse	The act of moving a measuring point across the width of a flow channel.

U V W X Y Z

Uncertainty	The closeness of agreement between the result of a measurement and the true value of the measurement.
V	Velocity or voltage.
VAC	Volts, alternating current.
VDC	Volts, direct current.
VORTEX	An eddy of fluid.