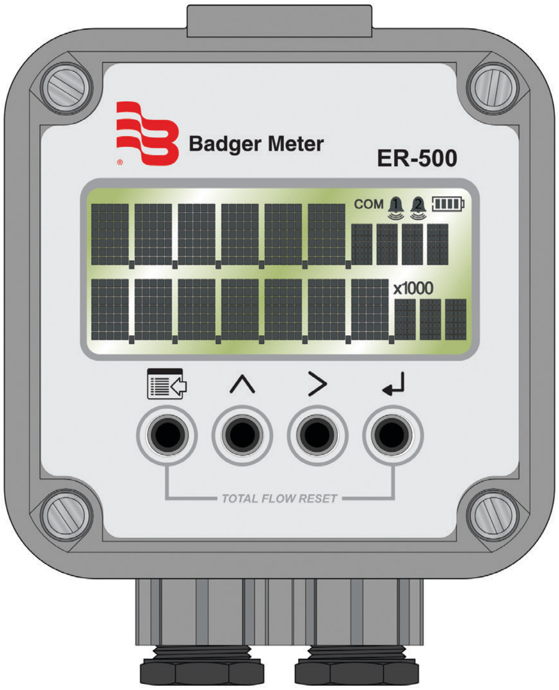
Display

ER-500 Advanced



DSY-PM-00028-EN-02 (February 2017)

Programming Manual

CONTENTS

SCOPE OF THIS MANUAL

This manual is intended to help you get the ER-500 flow monitor up and running quickly.

IMPORTANT

Read this manual carefully before attempting any installation or operation. Keep the manual accessible for future reference.

UNPACKING AND INSPECTION

Upon opening the shipping container, visually inspect the product and applicable accessories for any physical damage such as scratches, loose or broken parts, or any other sign of damage that may have occurred during shipment.

NOTE: If damage is found, request an inspection by the carrier's agent within 48 hours of delivery and file a claim with the carrier. A claim for equipment damage in transit is the sole responsibility of the purchaser.

SAFETY

Terminology and Symbols

⚠ DANGER	Indicates a hazardous situation, which, if not avoided, is estimated to be capable of causing death or serious personal injury.
⚠ WARNING	Indicates a hazardous situation, which, if not avoided, could result in severe personal injury or death.
⚠ CAUTION	Indicates a hazardous situation, which, if not avoided, is estimated to be capable of causing minor or moderate personal injury or damage to property.

Considerations

The installation of the ER-500 flow monitor must comply with all applicable federal, state, and local rules, regulations, and codes.

⚠ WARNING

EXPLOSION HAZARD - SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR CLASS I, DIVISION 2.

⚠ AVERTISSMENT

RISQUE D'EXPLOSION - LA SUBSTITUTION DE COMPOSANTS PEUT RENDRE CEMATÉRIEL INACCCEPTABLE POUR LES EMPLACEMENTS DE CLASSE I, DIVISION 2.

⚠ WARNING

DO NOT CONNECT OR DISCONNECT EITHER POWER OR OUTPUTS UNLESS THE AREA IS KNOWN TO BE NON-HAZARDOUS.

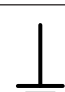
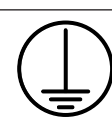
⚠ AVERTISSMENT

RISQUE D'EXPLOSION. NE PAS DÉBRANCHER TANT QUE LE CIRCUIT EST SOUSTENSION, À MOINS QU'LL NE S'AGISSE D'UN EMPLACEMENT NON DANGEREUX.

IMPORTANT

Not following instructions properly may impair safety of equipment and/or personnel.

Electrical Symbols

Function	*Direct Current*	*Alternating Current*	*Earth (Ground)*	*Protective Ground*	*Chassis Ground*
Symbol					

INTRODUCTION

The ER-500 flow monitor incorporates state-of-the-art digital signal processing technology designed to provide the user with exceptional flexibility at a very affordable price. Though designed for use with Badger Meter® flow sensors, this monitor can be used with almost any flow sensor producing a low amplitude AC output or contact closure signal.

The ER-500 monitor uses contact closures from an ILR transmitter that translates to flow rate through the use of a scaling constant called a K-factor.

This monitor is also capable of accepting low-level frequency input signals typically found in flow sensors that generate a frequency output. The output signal for these type of sensors is a frequency proportional to the rate of flow. The ER-500 monitor uses the frequency information to calculate flow rate and total flow. If required, the flow monitor can easily be re-configured in the field.

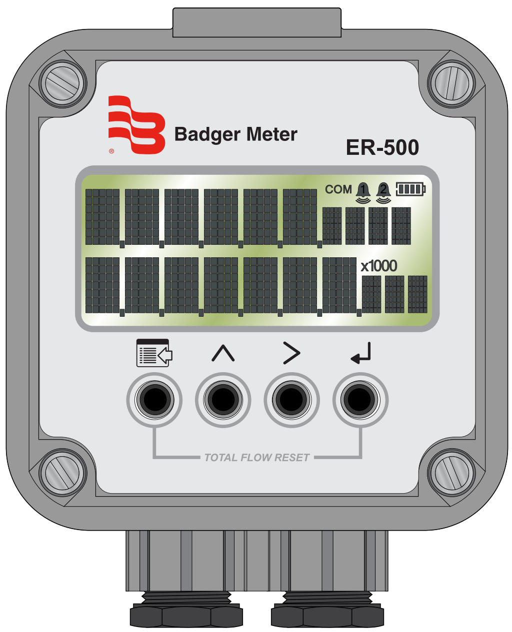


Figure 1: ER-500 monitor

The monitor is available in two different levels of functionality. The standard model provides all the functions necessary for the most common flow metering applications. The advanced version adds communications capabilities over an RS485 bus using Modbus RTU and control outputs.

INSTALLATION

Connecting the ER-500 Monitor to a Pulse Output Device

The ER-500 monitor has two jumpers that are used to set the type of signal and the minimum amplitude of the signal that it accepts. When used with Badger Meter IOG oval gear meters, the Input Signal Level should be set to *Low* and the Input Waveform should be set for pulse as shown in *Figure 2*.

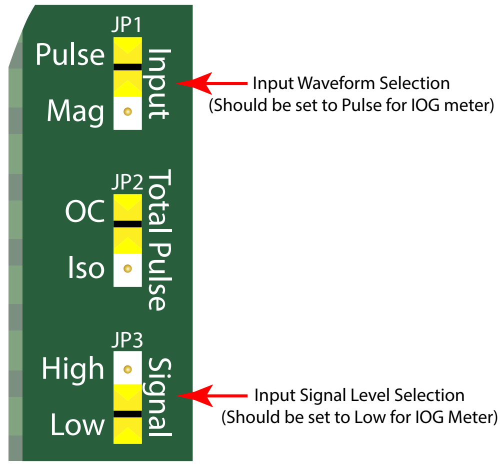


Figure 2: Input jumper settings

If the ER-500 monitor is a replacement, it must be calibrated for the IOG it is intended to be used with. The K-factor for the specific IOG meter must be programmed into the ER-500 monitor. The K-factor value is found on the calibration certificate that came with the IOG meter. For instructions on programming the K-factor, see *Enter Flow Sensor's K-factor* on page 17*.

Transmitter Connections

The ILR transmitter typically used with the IOG meter family has two sets of pulse output wires. The white and green output leads connected to the primary reed switch bank are generally the first choice (see *Figure 3*).

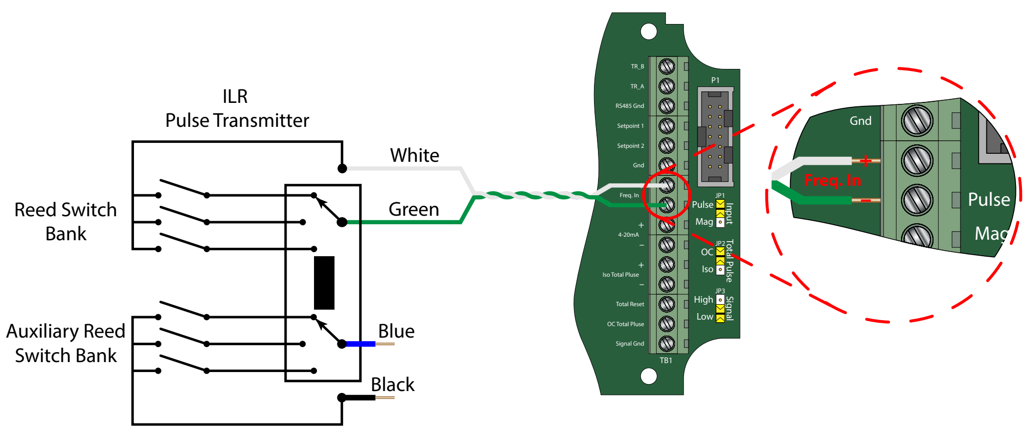


Figure 3: Typical IOG meter input connection

The ILR transmitter also has a secondary (auxiliary) set of pulse output wires. Either pair can be used to connect to the ER-500 monitor. The connections are:

	ILR Wires	
ER-500 Terminals	**Reed Switch Bank (Primary)**	**Reed Switch Bank (Auxiliary)**
Freq. In +	White	Blue
Freq. In -	Green	Black

Power Connections

The ER-500 monitor has two power supply options. The first power supply is an internal lithium 3.6V DC D size cell that powers the monitor for about six years when no outputs are used. The monitor can also be powered by a 4…20 mA current loop. See *Figure 4*. If the current loop is used, a sensing circuit within the monitor detects the presence of the current loop and automatically disconnects the battery from the circuit.

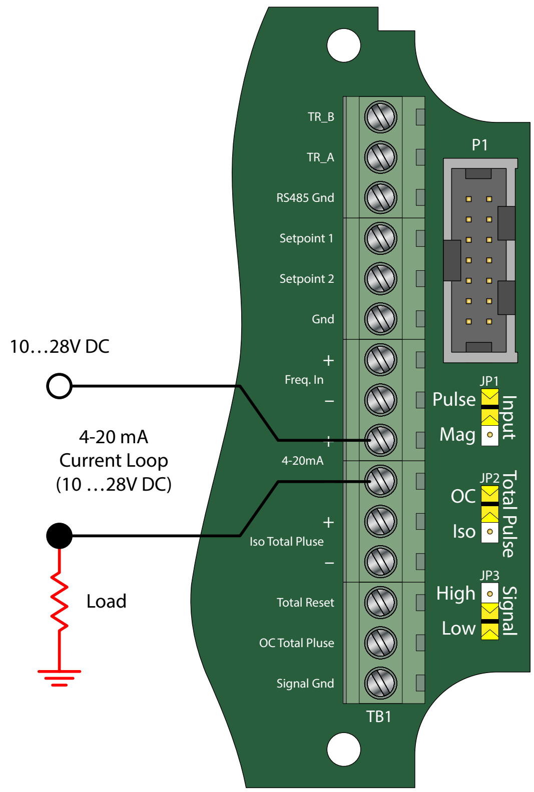


Figure 4: Loop power connections

OPERATING THE MONITOR

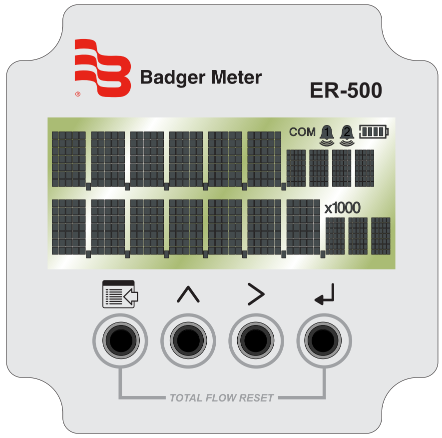


Figure 5: Keypad detail

Buttons

MENU	Switches between *RUN* and *PROGRAMMING* modes
UP	Scrolls backwards through the parameter options, increments numeric variables and scrolls backward through parameters
RIGHT	Scrolls forward through the parameter options, moves the active digit to the right and scrolls forward through parameters
ENTER	Saves programming information, advances to the next programming parameter, and used in the reset process

Special Functions

MENU + ENTER	Simultaneously press and hold to reset the current totalizer
MENU	Press and hold for three seconds to enter *Extended Programming* mode
UP+ RIGHT	Simultaneously press and hold to show the firmware version number, then the grand total

Modes

RUN	Normal operating mode
PROGRAM	Used to program parameters in the display
EXTENDED PROGRAMMING	Used to program advanced variables into the display
TEST	Used as a diagnostic tool to show input frequency and totalizer counts

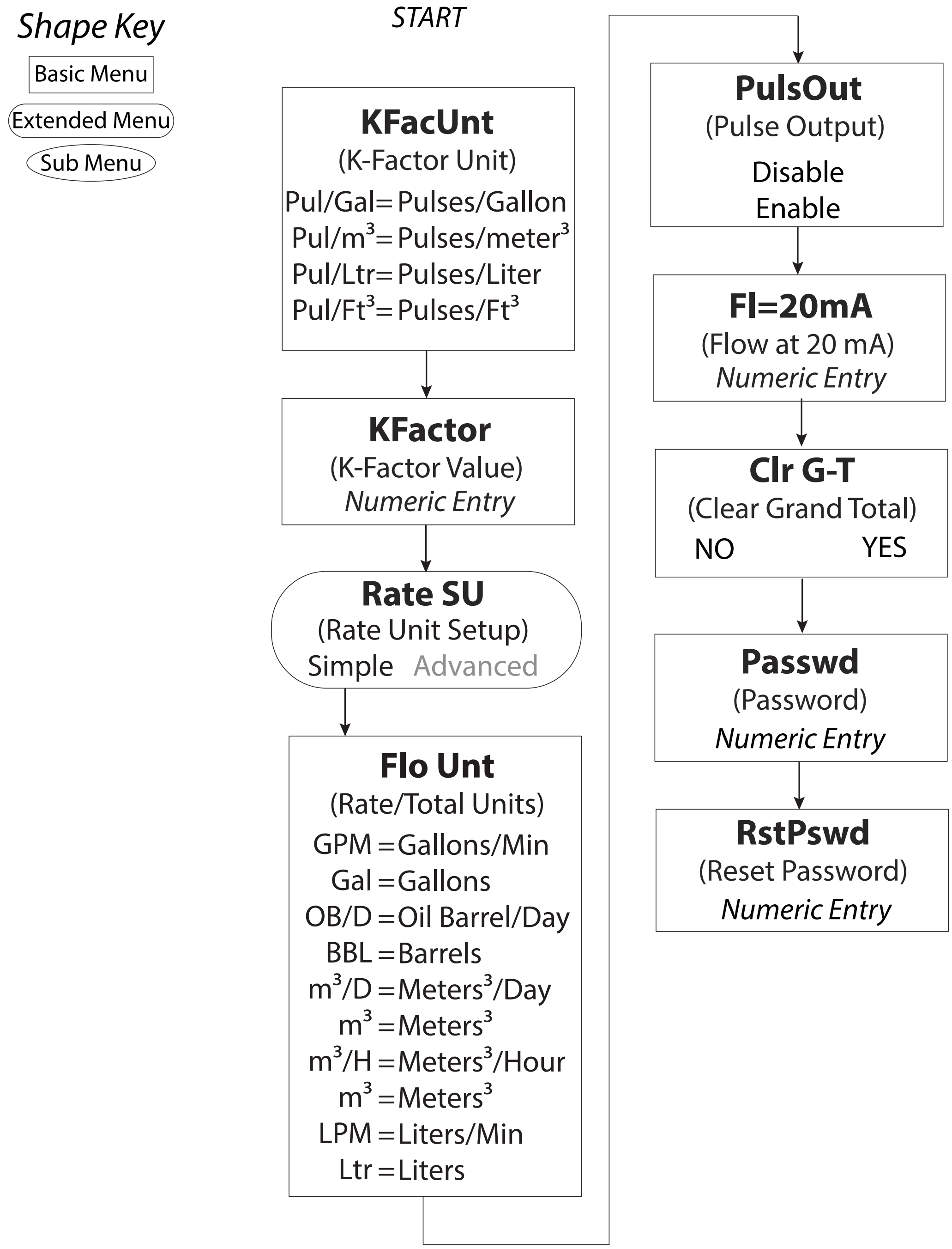
If the monitor is a replacement, the K-factor of the flow sensor has changed, or the monitor is being used with some other pulse generating device, programming is necessary.

Programming Using Frequency Output Flow Sensors

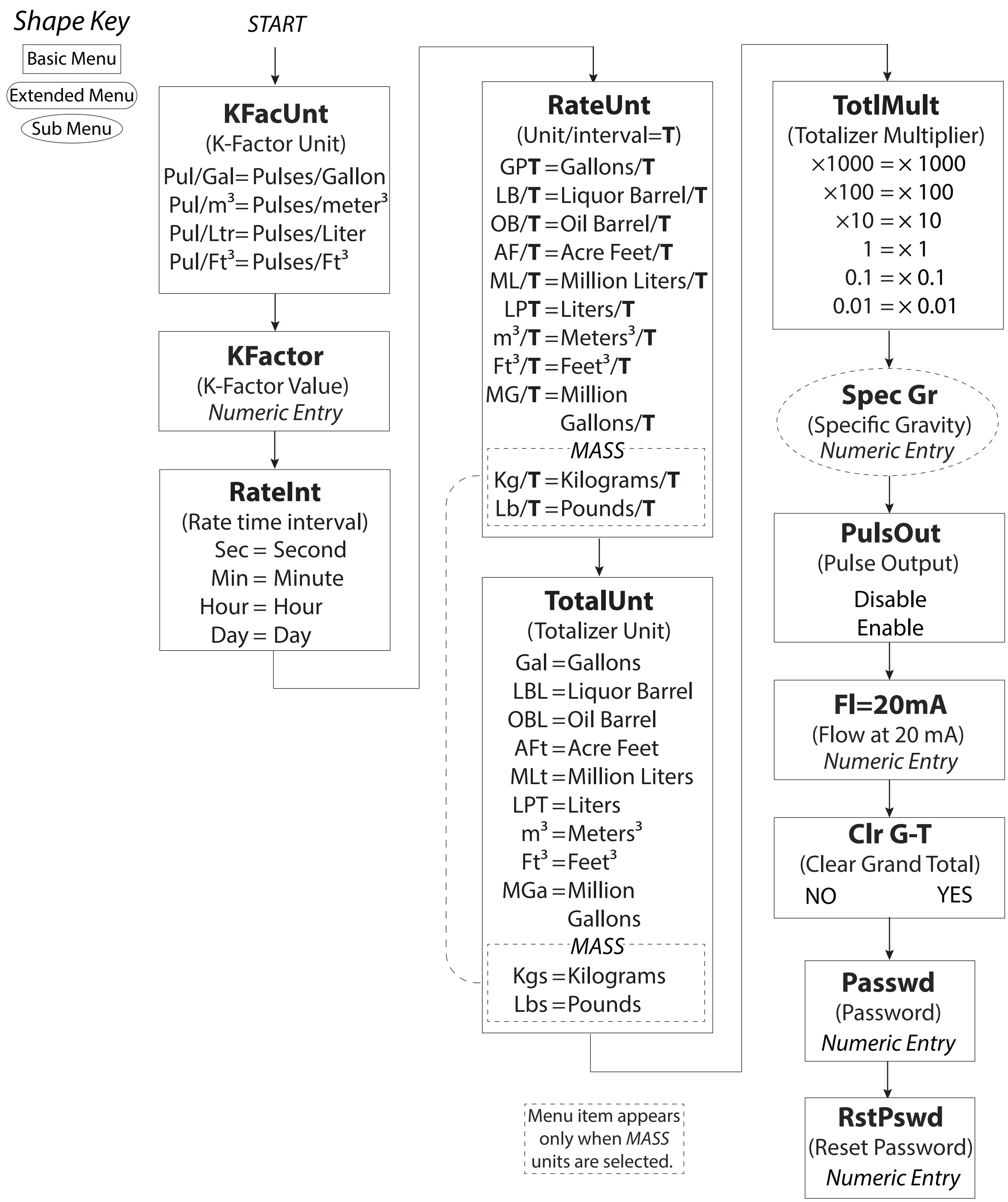
Each Badger Meter flow sensor is shipped with either a K-factor value or frequency data. If frequency data is provided, the data must be converted to a K-factor before programming the monitor. The K-factor represents the number of pulses per unit of volume. See *Connecting the ER-500 Monitor to a Pulse Output Device on page 7*. The K-factor is needed to program the monitor.

MENU STRUCTURE

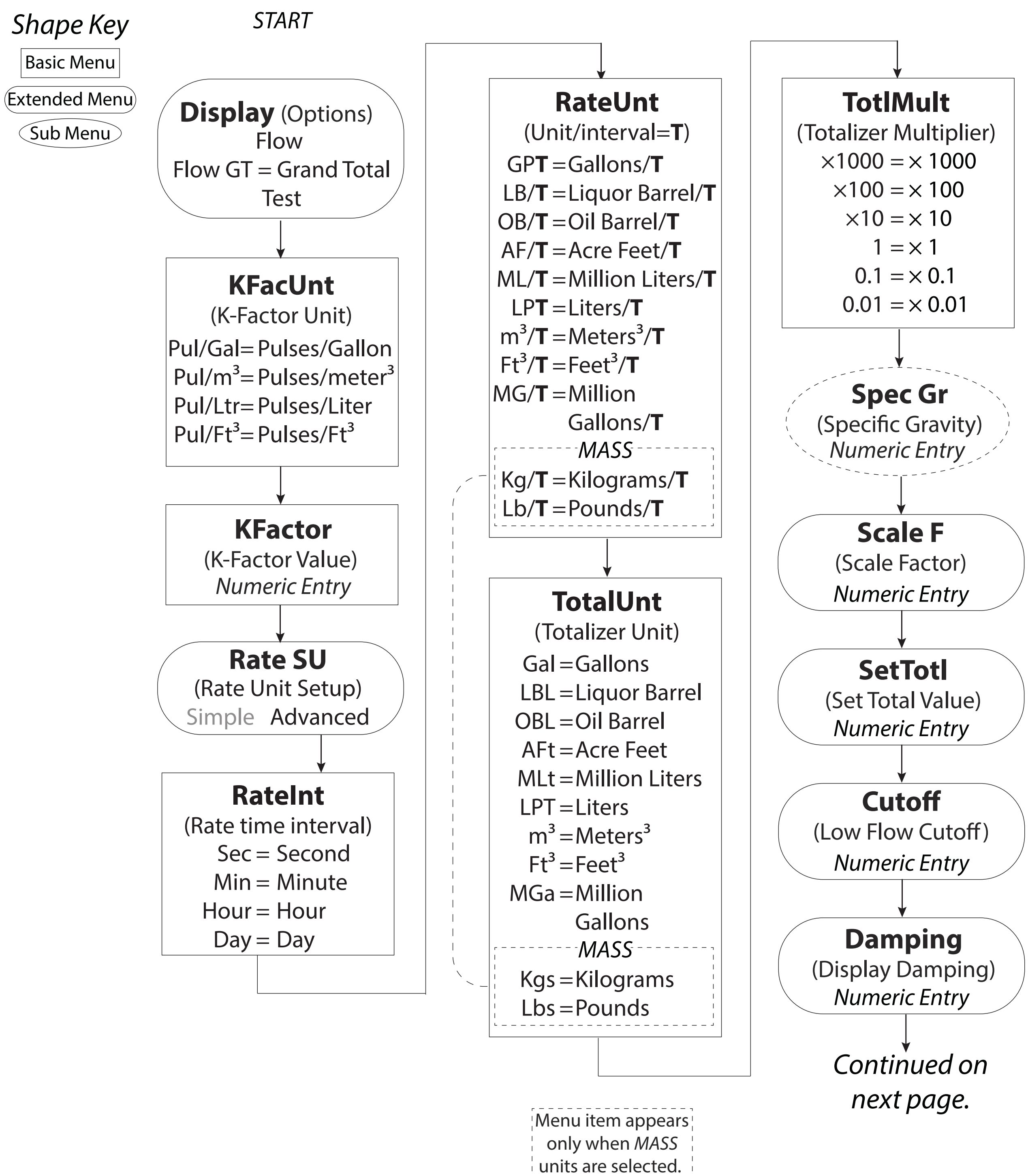
Standard ER-500, Rate SU is Set to Simple



Advanced ER-500, Basic Menu



Standard ER-500, Rate SU is Set to Advanced



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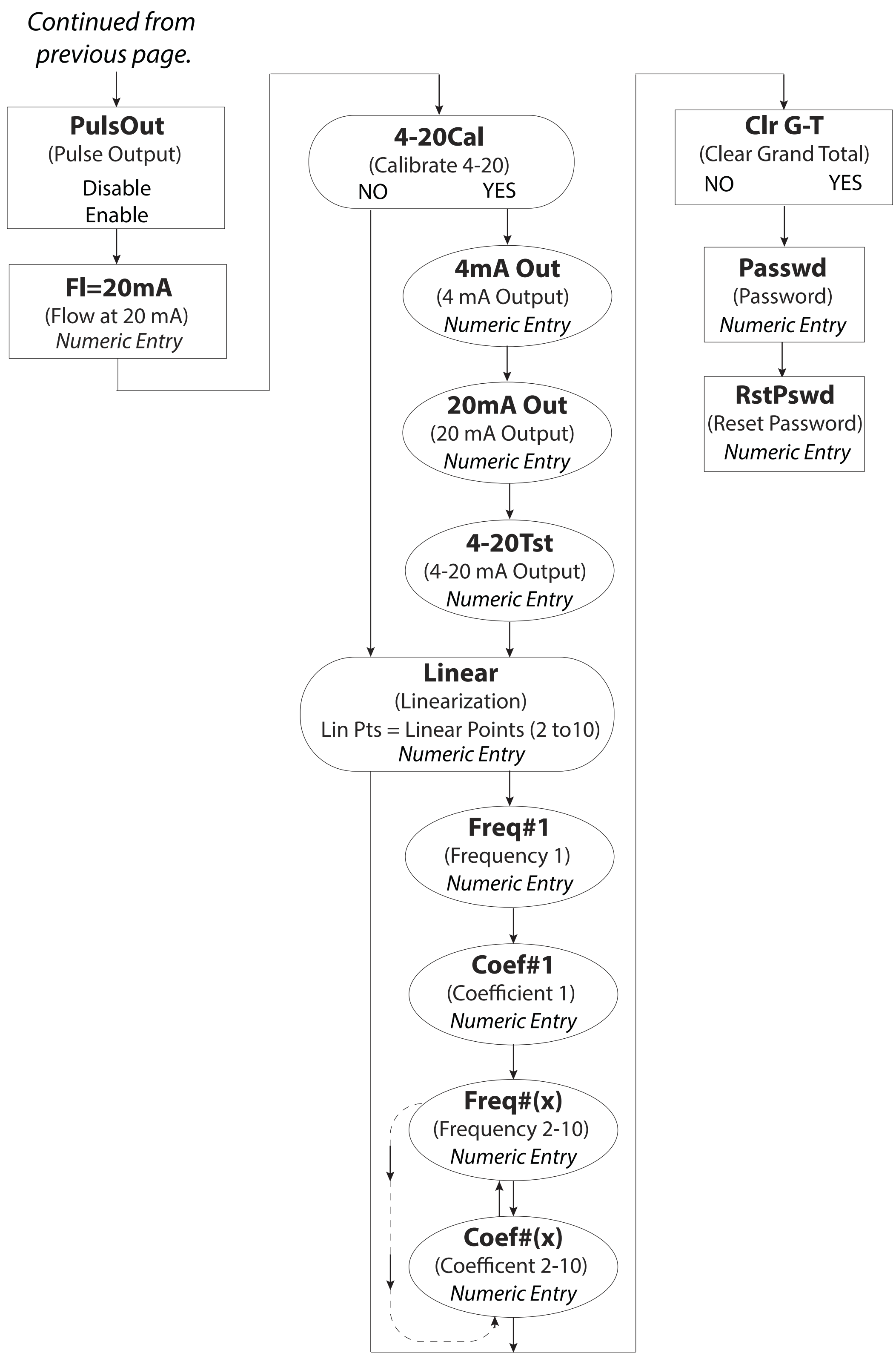
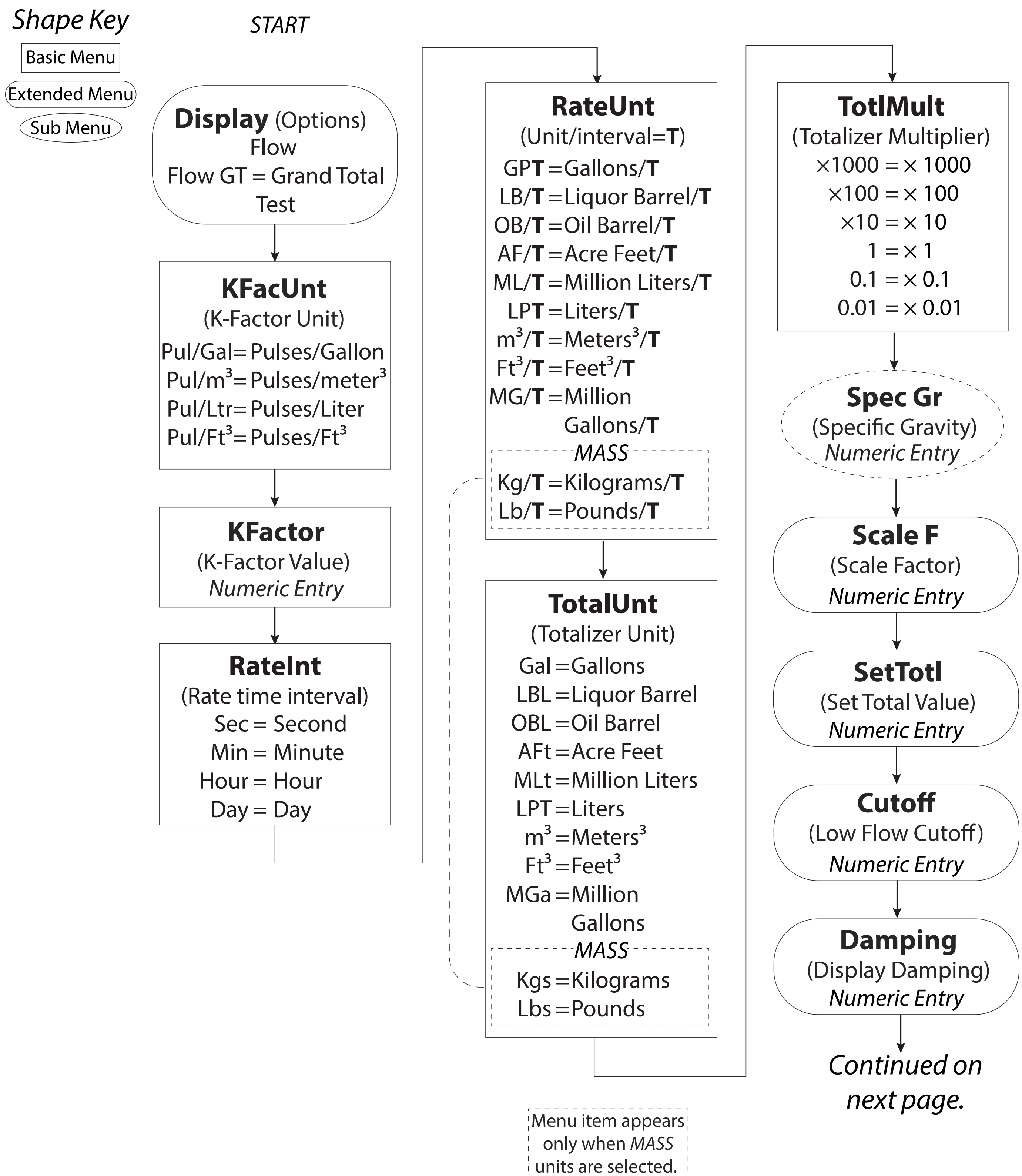
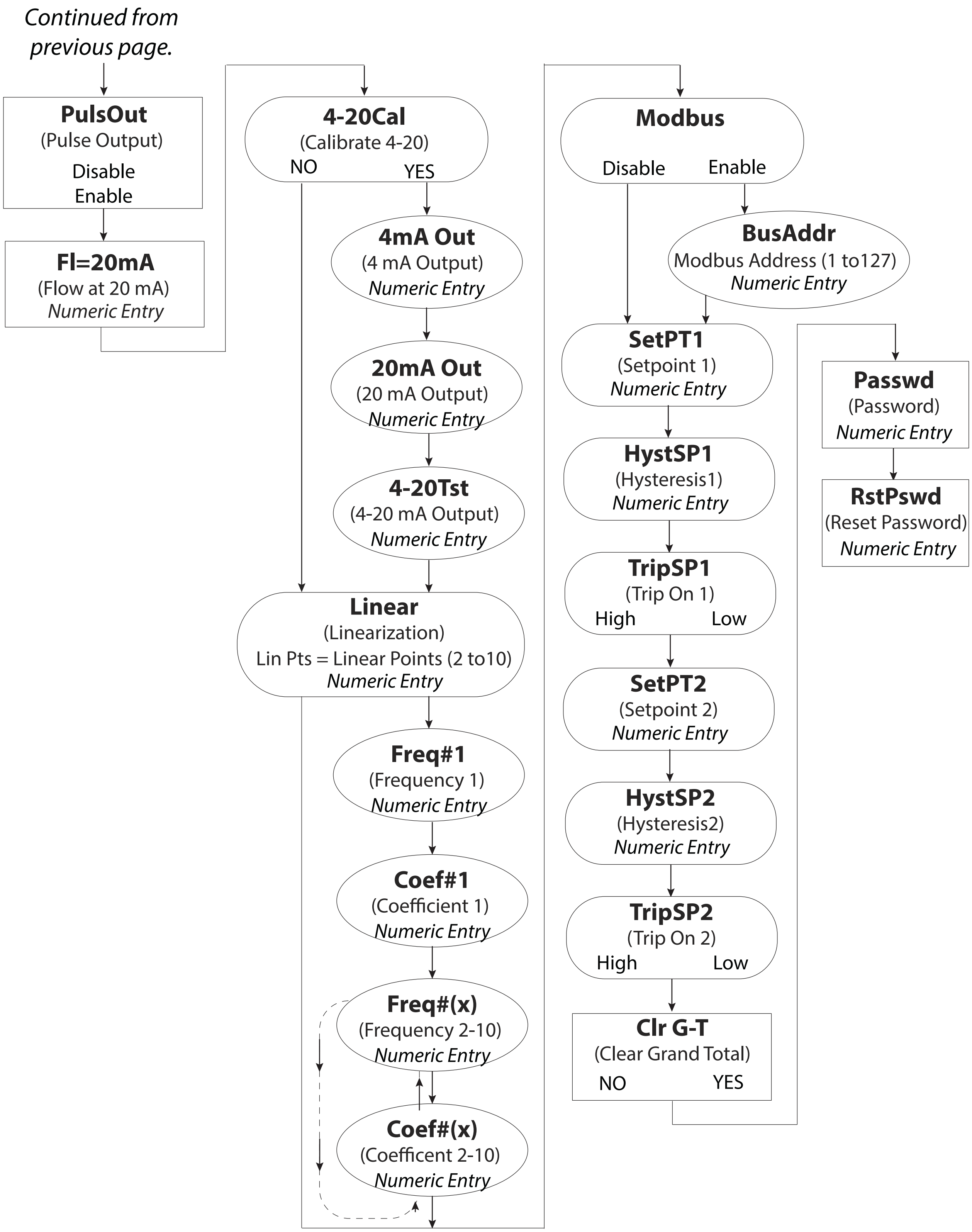
Standard ER-500, Rate SU is Set to Advanced (continued)



Advanced ER-500, Advanced Menu



Advanced ER-500, Advanced Menu (continued)



PROGRAMMING

NOTE: All of the following parameters appear in *Extended Programming* mode. Parameters with an asterisk (*) appear in *Programming* mode as well.

Parameters

Select Display Function

The ER-500 monitor has three display selections— *Flow*, *Grand Total* and *Test*.

Flow

Use the *Flow* setting for normal operation of the monitor. In this mode, the display shows both the instantaneous flow rate and current total simultaneously, see *Figure 6*.

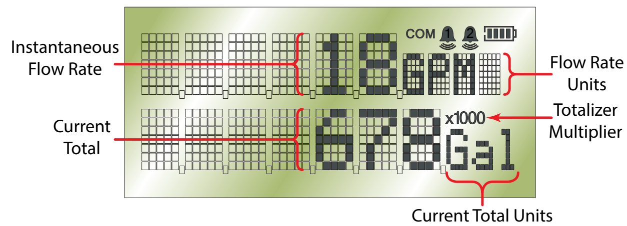


Figure 6: Instantaneous flow rate and current total

Flow Grand Total

The *Flow-GT* setting forces the meter to alternate between the instantaneous flow and the grand total with roll-over counts, see *Figure 7*.

The grand total is the accumulation of all the fluid that has gone through the meter since the last time the grand total was cleared. This totalizer is in addition to the current total totalizer on the display and is always enabled.

In addition, the grand total screen displays the number of times the grand total has reached its maximum count (9,999,999) and rolled over to zero.

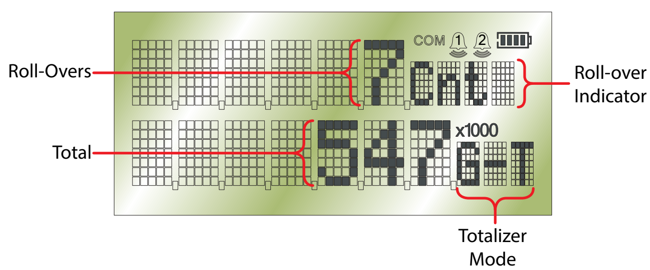


Figure 7: Grand total

Test

The *Test* setting places the monitor into a special diagnostic mode that shows the current input frequency and the accumulated input counts. *Figure 8* shows the layout for test mode values. The diagnostic mode makes it possible for you to see precisely the frequency input the monitor is seeing and is very useful in troubleshooting and electrical noise detection.

At the *Display* prompt, press **ENTER** to view the current display setting. If the current display setting is correct, press **ENTER** to advance to the next parameter. To change the display setting, press **UP** or **RIGHT** to scroll through the display options. Press **ENTER** to save and advance to the *KFacUnit* parameter.

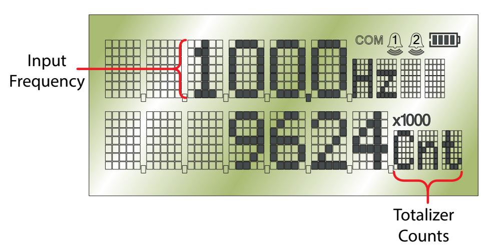


Figure 8: Test mode screen

Select Display's K-factor Unit*

At the *KFacUnt* prompt, press **ENTER**. The display shows the current K-factor unit. If the current selection is correct, press **ENTER** to advance to the next parameter. To change the K-factor unit, press **UP** or **RIGHT** to scroll to the correct unit. The units should match the units that the meter was calibrated in. Press **ENTER** to save and advance to the *KFactor* parameter.

Enter Flow Sensor's K-factor*

NOTE: The K-factor supplied with your meter or calculated from calibration data is needed to complete this step.

At the *KFactor* prompt, press **ENTER**. The most significant digit in the K-factor flashes. If the current K-factor is correct, press **ENTER** to advance to the next parameter. To change the K-factor, press **UP** to increment the digit until it matches the meter's first K-factor digit. Press **RIGHT** to advance to the next digit. Repeat this process until all K-factor digits have been entered. Press **ENTER** to save the K-factor and advance to the *RateInt* parameter.

NOTE: The number of digits available before and after the decimal point is determined by the bore size of the flow sensor being used. The largest K-factors are associated with the smallest bore sizes. The maximum allowable K-factor is 99999.9. The minimum must be at least 1.000. If an out-of-range number is entered, the display flashes *Limit* and refuses the entry.

Select Rate (Time) Interval*

At the *RateInt* prompt, press **ENTER**. The monitor flashes the current time interval. If the current selection is correct, press **ENTER** to advance to the next parameter. To change to an alternate time interval, press **UP** or **RIGHT** to scroll to the correct time interval. Press **ENTER** to save and advance to the *RateUnt* parameter.

Select Flow Rate Units*

At the *RateUnt* prompt, press **ENTER**. The monitor flashes the current rate unit. If the current selection is correct, press **ENTER** to advance to the next parameter. To change to an alternate unit, press **UP** or **RIGHT** to scroll to the correct rate unit and press **ENTER** to save and advance to the *TotlUnt* parameter.

Select Units of Measure for Total*

At the *TotlUnt* prompt, press **ENTER**. The monitor flashes the current total units. If the current selection is correct, press **ENTER** to advance to the next parameter. To change to an alternate unit, press **UP** or **RIGHT** to scroll to the correct totalization unit. Press **ENTER** to save and advance to the *TotlMul* parameter.

Select a Total Multiplier*

This parameter displays the accumulated flow total in multiples of 10. For example, if the optimum totalization unit is 1000 gallons, the unit total display increments by one digit for every 1000 gallons monitored. In *Run* mode, at 1000 gallons the total monitor reads 1, at 3000 gallons, the total display reads 3. This feature eliminates having to look at a total, count the digits, and mentally insert commas for each 1000 multiple.

At the *TotlMul* prompt, press **ENTER** . The monitor shows the current total multiplier. If the selection is correct, press **ENTER** to advance to the next parameter. To change to an alternate multiplier, press **UP** or **RIGHT** to scroll to the correct multiplier unit and press **ENTER** to and advance to the next parameter.

NOTE: If the *RateUnt* or *TotlUnt* parameter has been set to pounds or kilograms, the monitor advances to the *Spec Gr* parameter. At any other setting, the monitor advances to *Scale F*. If pounds or kilograms have not been chosen, see *Enter a Scale Factor on page 18*.

NOTE: If you are in *Programming* mode, the monitor advances to the *PulsOut* parameter.
See *Totalizer Pulse Output* on page 19*.

Enter a Specific Gravity Value*

Mass readings in the ER-500 monitor are not temperature or pressure compensated so it is best to enter the specific gravity of the fluid as close to the system running temperature as possible. As liquids are essentially incompressible, pressure compensation is not necessary for liquids.

At the *Spec Gr* prompt, press **ENTER**. The most significant digit of the current specific gravity flashes. If the current specific gravity is correct, press **ENTER** to advance to the next parameter. To change to an alternate specific gravity, press **UP** to increment the flashing digit until you reach the first digit of the new specific gravity. Press **RIGHT** to move to the next digit. When all digits have been entered, press **ENTER** to save and advance to the *Scale F* parameter.

Enter a Scale Factor

The scale factor is used to force a global span change. For example, in *Run* mode the display is reading a consistent three percent below the expected values at all flow rates. Rather than changing the K-factor and linearization parameters individually, the scale factor can be set to 1.03 to correct the readings. The range of scale factors is from 0.10…5.00. The default scale factor is 1.00.

At the *Scale F* prompt, press **ENTER**. The first digit of the existing scale factor flashes. If the current selection is correct, press **ENTER** to advance to the next parameter. To change to an alternate scale factor, press **UP** to increment the display digit until it matches the first digit of the new scale factor. Press **RIGHT** to advance to the next digit. Repeat for all digits. Press **ENTER** to save and advance to the *SetTotl* parameter.

NOTE: If the number you enter is out of range, the display flashes *Limit* and refuses the entry.

Preset Total

The preset total parameter sets the totalizer to a predetermined amount. The preset can have seven digits up to 8,888,888.

At the *SetTotl* prompt, press **ENTER**. The monitor displays the current set total. If the set total is correct, press **RIGHT** to advance to the next parameter. To change the set total, press **ENTER** again. The first digit of the current preset total flashes. Press **UP** to increment the display digit until it matches the first digit of the correct preset. Press **RIGHT** to advance to the next digit. Repeat for all digits. Press **ENTER** to save and advance to the *Cutoff* parameter.

NOTE: If the number you enter is out of range the display, flashes *Limit* and refuses the entry.

Low Flow Cutoff

The flow cutoff shows low flow rates (that can be present when pumps are off and valves are closed) as zero flow on the flow monitor. A typical value would be about five percent of the flow sensor's maximum flow.

Enter the low flow cutoff as an actual flow value. For example, if the maximum flow rate for the flow sensor was 100 gpm, set the low flow cutoff value to 5.0.

At the *Cutoff* prompt, press **ENTER**. The first digit of the current low flow cutoff flashes. If the current selection is correct, press **ENTER** to advance to the next parameter. To change the low flow cutoff, press **UP** to increment the display digit until it matches the first digit of the new low flow cutoff value. Press **RIGHT** to advance to the next digit. Repeat for all digits. Press **ENTER** to save and advance to the *Damping* parameter.

NOTE: If the number you enter is out of range the display, flashes *Limit* and refuses the entry.

Damping Factor

The damping factor is increased to enhance the stability of the flow readings. Damping values are decreased to allow the monitor to react faster to changing values of flow. This parameter can be any value between 0…99%, with 0 being the default.

At the *Damping* prompt, press **ENTER**. The most significant digit of the current setting flashes. If the current selection is correct, press **ENTER** to advance to the next parameter. To change the damping value, press **UP** to increment the display digit until it matches the new damping value. Press **RIGHT** to advance to the next digit. Press **ENTER** to save and advance to the *PulsOut* parameter.

Totalizer Pulse Output*

The *PulsOut* parameter can be either enabled or disabled. When enabled, this output generates a fixed width 30 mS duration pulse every time the least significant digit of the totalizer increments. The amplitude of the pulse is dependent on the voltage level of the supply connected to the pulse output and is limited to a maximum 28V DC.

At the PulsOut prompt, press **ENTER**. The monitor displays the current setting. If the setting is correct, press **ENTER** to advance to the next parameter. To change the parameter press **UP** or **RIGHT** to toggle between *Disable* and *Enable*. To save your selection, press **ENTER** to advance to the *Fl=20mA* parameter.

The ER-500 monitor provides two types of totalizer pulses. The basic open drain FET output provides a ground referenced output pulse that swings between about 0.7V DC and VCC, see *Figure 9 on page 19*.

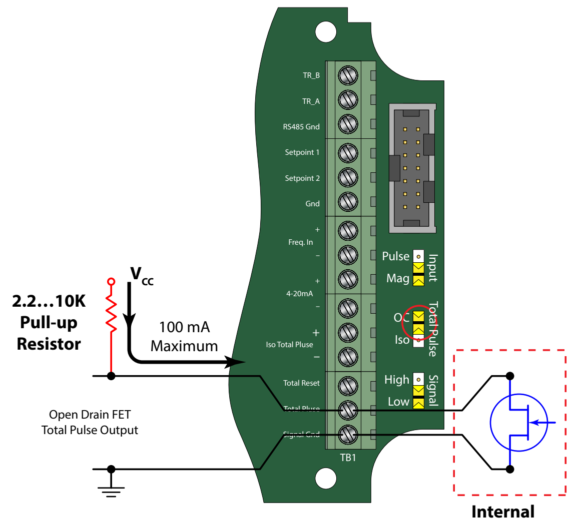


Figure 9: Open drain connections

The isolated pulse output (ISO), see *Figure 10*, is again an open collector output with the emitter of the transistor connected to the negative output terminal and is not referenced to ground. This output is optically isolated from the input signal for systems that require a totally isolated output pulse.

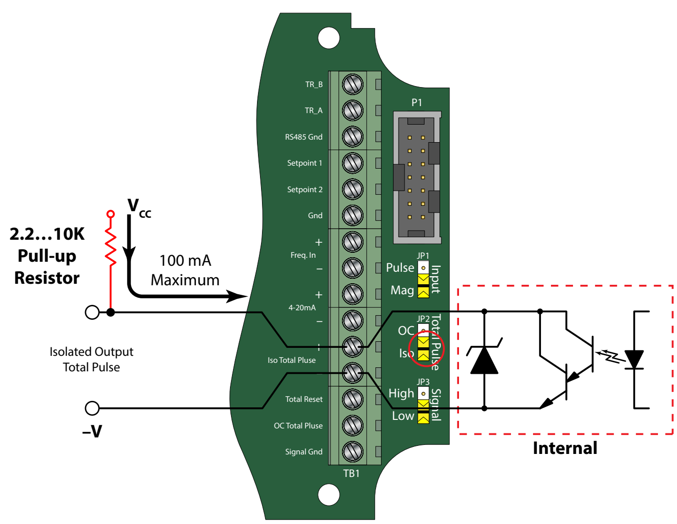


Figure 10: Opto-isolated open collector connections

Both outputs have a maximum current capacity of 100 mA and require a pull-up resistor. The value of the pull-up resistor is dependent on the supply voltage and the maximum current required by the load.

Flow 20 mA*

When the display is operated using loop power, the flow rate that corresponds to 20 mA must be set. This setting normally represents the maximum rate of the flow sensor connected to the display but other entries are possible.

At the *Fl=20mA* prompt, press **ENTER**. The first digit of the current setting flashes. If the current setting is correct, press **ENTER** to advance to the next parameter. If the current setting requires a change, press **UP** to increment the display digit until it matches the first digit of the required maximum flow value. Press **RIGHT** to advance to the next digit. Repeat for all of the maximum flow at 20 mA digits. Press **ENTER** to save and advance to the *4-20Cal* parameter.

NOTE: In *Programming* mode, the monitor advances to the *Clr G-T* parameter. See Clear Grand Total* on page 24.

4-20 mA Calibration

This setting allows the fine adjustment of the Digital to Analog Converter (DAC) that controls 4…20 mA output. The 4…20 mA output is calibrated at the factory and under most circumstances does not need to be adjusted. If the output needs to be adjusted for any reason the 4…20 mA calibration procedure is used.

At the *4-20Cal* prompt, press **ENTER**. The monitor displays *No*. If you do not need to complete the 4…20 mA calibration, press **ENTER** to advance to the *Linear* parameter. See *Linearization on page 21*. To complete the 4…20 mA calibration, press **UP** or **RIGHT** to change the display to *Yes*. Press **ENTER** to advance to the *4mA Out* parameter.

4 mA Adjustment
To set the *4mA Out* value, connect an ammeter in series with the loop power supply as shown in *Figure 11*. The 4 mA DAC setting is typically 35…50. At the *4mA Out* prompt, press **UP** to increase or **RIGHT** to decrease the current output while monitoring the ammeter. When a steady 4 mA reading is established on the ammeter, press **ENTER** on the monitor to save the output and advance to the *20mAOut* parameter.

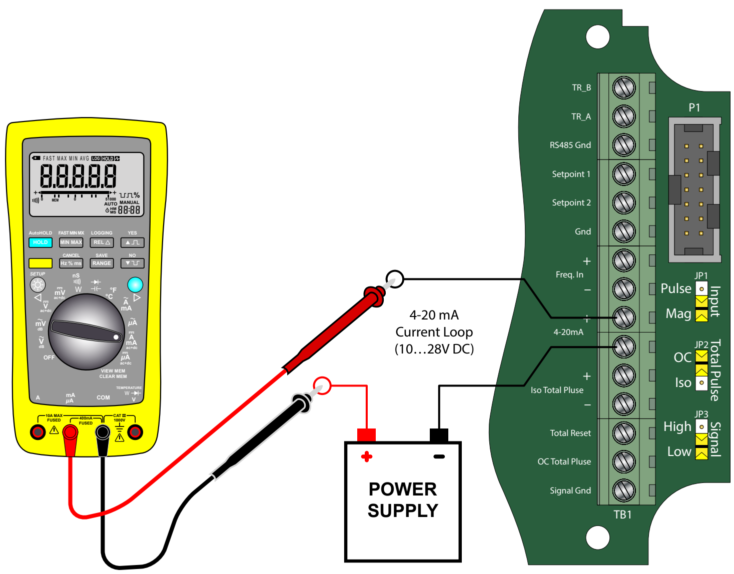


Figure 11: 4-20 mA calibration setup

20 mA Adjustment
The 20 mA adjustment is performed using the same procedure as the 4 mA adjustment.

4-20 mA Test
The ER-500 monitor contains a diagnostic routine that allows the simulation of mA output values between 4 …20 to check output tracking. At the *4-20Tst* prompt, the current flashes. Press **UP** to increase the simulated mA output in increments of 1 mA. Press **RIGHT** to decrease the mA output. The ammeter should track the simulated mA output. If a 4…20 mA test is not necessary, press **ENTER** to advance to the *Linear* parameter.

NOTE: Press **ENTER** when the monitor is in test mode to exit the test mode and move on to the next programming parameter.

Linearization

To increase accuracy, linearize the monitor. The linearization function accepts a maximum of ten points and requires additional calibration data from the meter being used with the monitor. Typically, calibration information can be obtained in three, five and ten points from the flow meter's manufacturer. If linearization is not needed, press **RIGHT** to advance to the *Modbus* parameter. See Modbus on page 22. To complete linearization, press **ENTER** at the *Linear* prompt. The monitor advances to the *Lin Pts* parameter.

Number of Points
The *Lin Pts* value displays. If the number of points is set to *0*, linearization is disabled. Press **ENTER.** The most significant digit of the number of points entry begins to flash. The first number can be a *1* or a *0* only. Press **UP** to change the first digit. Press **RIGHT** to move to the least significant digit.

NOTE: If the number you enter is out of range the, display flashes *Limit* and refuses the entry.

Press **ENTER** to advance to the *Freq#1* prompt.

NOTE: If the number of linear points is set to 1, the ER-500 monitor assumes that you are entering the maximum frequency and coefficient. Further, the meter assumes that the implied first point is at a frequency of 0 Hz and a coefficient of 0.

Frequency
At the *Freq#1* prompt, press **ENTER**. The first digit of the first linear point's frequency input flashes. Press **UP** to increment the numerical values and **RIGHT** to change the position of the number being entered. When the frequency value input is complete, press **ENTER** to save and advance to the *Coef#1* parameter.

Coefficient
The coefficient is the value applied to the nominal K-factor to correct it to the exact K-factor for that point. The coefficient is calculated by dividing the average (nominal) K-factor for that point by the actual K-factor for the flow meter.

$$\text{Linear Coefficient} = \frac{\text{Nominal K-Factor}}{\text{Actual K-Factor}}$$

At the *Coef#1* prompt, press **ENTER**. The first digit of the coefficient flashes. Press **UP** to increment the digit, and **RIGHT** to move to the next digit. When all digits have been entered, press **ENTER** to save and advance to the next frequency input.

Continue entering pairs of frequency and coefficient points until all data has been entered. Press **ENTER** to save and advance to the *Modbus* parameter.

NOTE: The frequency values must be entered in ascending order. If a lower frequency value is entered after a higher value the ER-500 monitor flashes *Limit* followed by the minimum frequency value acceptable to the display.

Example:
The following is actual data taken from a one inch turbine flow sensor calibrated with water.

Unit Under Test (UUT) Calibration In GPM					
Actual GPM	UUT Frequency	UUT Actual K-factor	(Hz x 60) Nominal K	Linear Coefficient	Raw Error
	Hz	Counts/Gallon	GPM		% Rate
50.02	755.900	906.72	49.72	1.0060	0.59
28.12	426.000	908.96	28.02	1.0035	0.35
15.80	240.500	913.29	15.82	0.9987	-0.13
8.88	135.800	917.57	8.93	0.9941	-0.59
4.95	75.100	910.30	4.94	1.0020	0.20
Nominal K (NK)		912.144		—	—

In this example the linear coefficient has already been calculated by the calibration program so all that is required is to enter five into the *Lin Pts* parameter and then enter, in order, the five frequency and linear coefficient data pairs.

Modbus

The Modbus output parameter can be either enabled or disabled. When enabled, this output allows communications with the ER-500 monitor using the Modbus RTU protocol. For additional information see *Modbus Interface on page 27*.

At the *Modbus* prompt, press **ENTER**. The current state of the Modbus output is shown. If the current state is correct, press **ENTER** to advance to the next parameter. To change the modbus setting, press **UP** or **RIGHT** to toggle between states. When the proper state displays, press **ENTER** to save and advance to the *BusAddr* parameter.

Bus Address
If the Modbus output is enabled, you must choose a valid Modbus address. Every device communicating over the RS485 communications bus using the Modbus protocol must have a unique bus address. Address values range from 0…127 with 0 being the default.

At the *BusAddr* prompt, press **ENTER**. The first digit of the address flashes. If the current setting is correct, press **ENTER** to advance to the next parameter. To change the address, press **UP** to increment the display digit until it matches the first digit of the new bus address. Press **RIGHT** to advance to the next digit. Repeat for all digits of the address. Press **ENTER** to save the new address and advance to the *SetPt 1* parameter.

Setpoints

Setpoints allow the meter to signal when a specific flow condition has been achieved. They are commonly used to indicate high or low flow conditions that need attention. The ER-500 monitor has two open collector outputs controlled by the setpoint function.

The setpoint transistors have the same current limitations and setup requirements as the totalizing pulse output transistors described previously. See *Figure 12 on page 23* for control output transistor connections.

Both setpoint 1 and setpoint 2 are configured using the same procedures, but the hysteresis and tripping conditions can be different for each setpoint output.

NOTE: In most instances, the current capacity of an open collector transistor is not sufficient to operate old style counters that relied on relay contact closures. When used with basic counting circuits, a solid-state relay is needed. See *Figure 13 on page 23* for a connection example.

Setpoint 1

The setpoint is the flow value at which the output transistor changes state. It is set using the same units as the rate units.

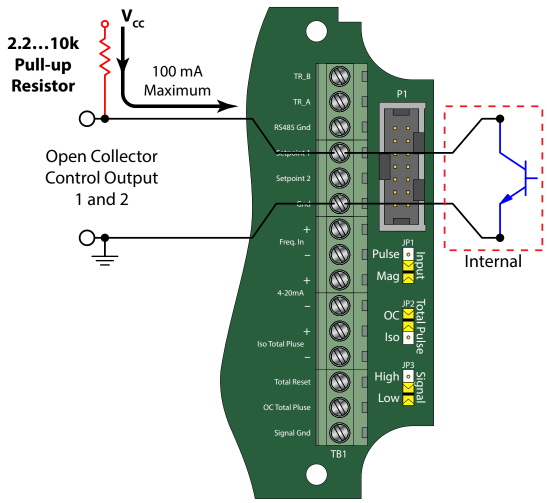


Figure 12: Setpoint output

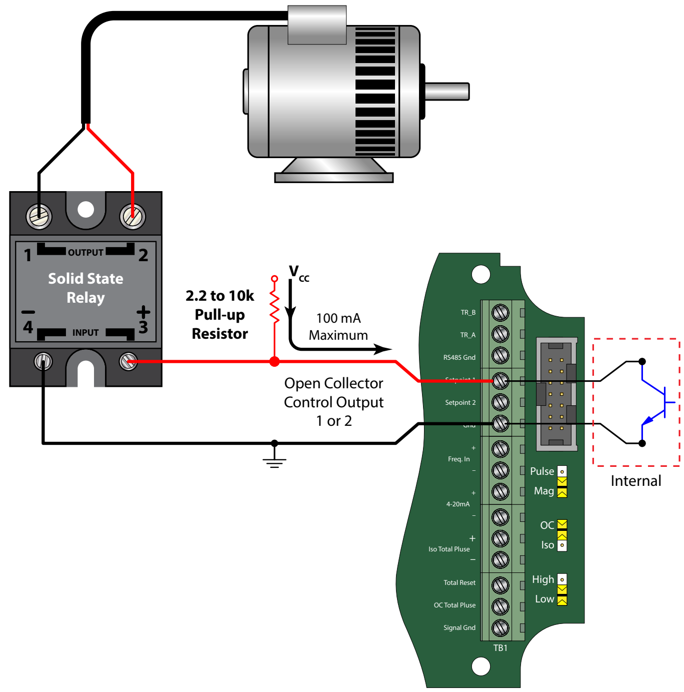


Figure 13: Typical solid state relay connections

At the *SetPt 1* prompt, press **ENTER**. The most significant digit of the current setting flashes. If the current setting is correct, press **ENTER** to advance to the next parameter. To change the current setting, press **RIGHT** to advance to the first digit of the required set point value. Press **UP** to increment the digit until it matches the first number of the required set point. Repeat for all the digits the set point. Press **ENTER** to save the new set point and advance to the *HystSP1* parameter.

Hysteresis 1

Hysteresis is used to modify how the output transistor reacts around a setpoint by taking recent history into account. Hysteresis prevents an output from turning on and off rapidly when the programmed flow rate is at or very near the setpoint.

For example, a low flow alarm is set to activate when the flow falls below a pre-programmed point. When the flow is reduced to the setpoint, even minute changes of flow above the setpoint turns the output off, disabling the alarm. Without hysteresis, if the flow rate fluctuates slightly above and below the setpoint, the output rapidly cycles between on and off states. See *Figure 14*. The hysteresis value is set using the same units as the rate units.

At the *HystSP1* prompt, press **ENTER**. The most significant digit of the current setting flashes. If the current setting is correct, press **ENTER** to advance to the next parameter. To change the current setting, press **RIGHT** to advance to the first digit of the required hysteresis value. When the correct place is reached, press **UP** to increment the digit until it matches the first number of the required hysteresis. Press **RIGHT** to advance to the next digit of the required hysteresis value and press **UP** to increment the display digit until it matches the next digit of the required hysteresis. Repeat this step for the all the digits of the hysteresis and then press **ENTER** to save the new hysteresis and advance to the next parameter.

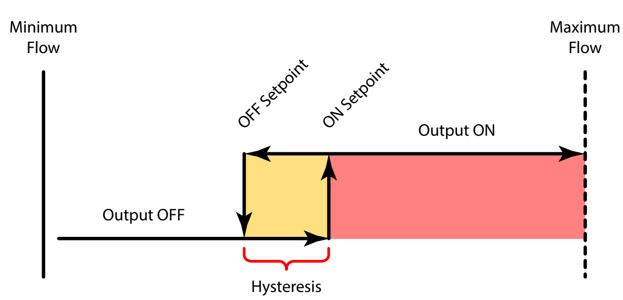


Figure 14: Setpoint actions

Trip SP 1

The trip parameter can be set for either *High* or *Lo*. When set to high, the open collector transistor stops conducting and sends the output high when the setpoint is reached. The output will not go low again until the flow rate falls below the setpoint minus the hysteresis value. When set to low, the open collector transistor starts conducting and sends the output low when the setpoint is reached. The output will not go high again until the flow rate exceeds the setpoint plus the hysteresis value.

For example, if the set point is 10 gpm, the hysteresis is set to 2 gpm and the trip setpoint is set to *High* (see *Figure 15*). When the flow goes above 10 gpm the OC transistor stops conducting and the output goes high. The output stays high until the flow rate drops below 8 gpm which is the setpoint (10 gpm) minus the hysteresis (2 gpm).

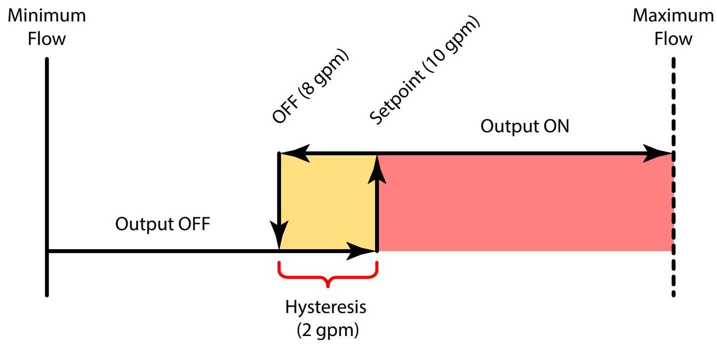


Figure 15: Setpoint example

At the *TripSP1* prompt, press **ENTER**. The tripping condition setting is displayed. If the current setting is correct, press **ENTER** to advance to the next parameter.

If the current setting requires a change, press **RIGHT** to advance to the alternate choice. Once the correct choice is displayed, press **ENTER** to save the new trip condition and advance to the next parameter.

Clear Grand Total*

At the *Clr G-T* prompt, press **ENTER**. The flow monitor displays *No*. To clear the grand total press, **UP** or **RIGHT** to change from *No* to *Yes*. Press **ENTER** to select *Yes* and advance to the next parameter. The totalizer can also be reset using a hardware reset as shown in *Figure 16*.

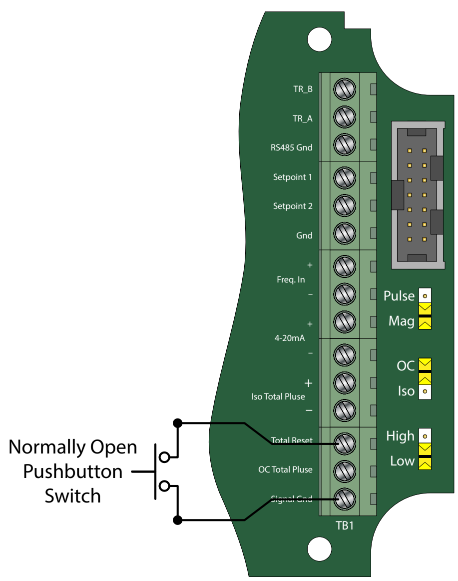


Figure 16: Hardware reset

Password*

The password setting restricts access to the *Programming* and *Extended Programming* modes. Initially, the password is set to all zeros and any user can modify the parameter settings. To change the password, press **ENTER** at the *Passwd* prompt. The first digit flashes. Press **UP** to increment the digit and **RIGHT** to advance to the next digit. After entering all digits, press **ENTER** to store the password and advance to *RstPswd*. The new password is now required to enter either programming mode. With this password set, any user is able to reset the stored totals on the monitor.

Reset Password*

The reset password parameter restricts resetting the totals on the monitor. The *Passwd* must also be set to restrict the total reset. Initially, the password is set to all zeros and any user can reset the stored totals on the monitor. To change the password, press **ENTER** at the *RstPswd* prompt. The first digit flashes. Press **UP** to increment the digit and **RIGHT** to advance to the next digit. After entering all digits, press **ENTER** to store the password and return to the *Fluid* parameter. The reset password is now required to reset the totals on the monitor.

NOTE: Entering a password in the *Passwd* screen and leaving the password blank in the *RstPswd* screen allows for total resets (not requiring a password), but restricts programming modification.

K-FACTORS EXPLAINED

The K-factor (with regards to flow) is the number of pulses that must be accumulated to equal a particular volume of fluid. You can think of each pulse as representing a small fraction of the totalizing unit.

An example might be a K-factor of 1000 (pulses per gallon). This means that if you were counting pulses, when the count total reached 1000, you would have accumulated 1 gallon of liquid. Using the same reasoning, each individual pulse represents an accumulation of 1/1000 of a gallon. This relationship is independent of the time it takes to accumulate the counts.

The frequency aspect of K-factors is a little more confusing because it also involves the flow rate. The same K-factor number, with a time frame added, can be converted into a flow rate. If you accumulated 1000 counts (one gallon) in one minute, then your flow rate would be 1 gpm. The output frequency, in Hz, is found simply by dividing the number of counts (1000) by the number of seconds (60) to get the output frequency.

$1000 \div 60 = 16.6666$ Hz. If you were looking at the pulse output on a frequency counter, an output frequency of 16.666 Hz would be equal to 1 gpm. If the frequency counter registered 33.333 Hz (2×16.666 Hz), then the flow rate would be 2 gpm.

Finally, if the flow rate is 2 gpm, then the accumulation of 1000 counts would take place in 30 seconds because the flow rate, and hence the speed that the 1000 counts is accumulated, is twice as great.

Calculating K-factors

Many styles of flow meters are capable of measuring flow in a wide range of pipe sizes. Because the pipe size and volumetric units the meter will be used on vary, it may not possible to provide a discrete K-factor. In the event that a discrete K-factor is not supplied then the velocity range of the meter is usually provided along with a maximum frequency output.

The most basic K-factor calculation requires that an accurate flow rate and the output frequency associated with that flow rate be known.

Example 1:

Known values are:

Frequency	=	700 Hz
Flow Rate	=	48 GPM

$$700 \text{ Hz} \times 60 \text{ sec} = 42{,}000 \text{ pulses per min}$$

$$\text{K-factor} = \frac{42{,}000 \text{ pulses per min}}{48 \text{ gpm}} = 875 \text{ pulses per gallon}$$

Example 2:

Known values are:

Full Scale Flow Rate	=	85 gpm
Full Scale Output Frequency	=	650 Hz

$650 \text{ Hz} \times 60 \text{ sec} = 39{,}000 \text{ pulses per min}$

$$\text{K-factor} = \frac{39{,}000 \text{ pulses per min}}{85 \text{ gpm}} = 458.82 \text{ pulses per gallon}$$

The calculation is a little more complex if velocity is used because you first must convert the velocity into a volumetric flow rate to be able to compute a K-factor.

To convert a velocity into a volumetric flow, the velocity measurement and an accurate measurement of the inside diameter of the pipe must be known. Also needed is the fact that 1 US gallon of liquid is equal to 231 cubic inches.

Example 3:

Known values are:

Velocity	=	4.3 ft/sec
Inside Diameter of Pipe	=	3.068 in.

Find the area of the pipe cross section.

$$\text{Area} = \pi r^2$$

$$\text{Area} = \pi \left(\frac{3.068}{2}\right)^2 = \pi \times 2.35 = 7.39 \text{ in}^2$$

Find the volume in 1 ft of travel.

$$7.3 \text{ in}^2 \times 12 \text{ in (1 ft)} = \frac{88.71 \text{in}^2}{\text{ft}}$$

What portion of a gallon does 1 ft of travel represent?

$$\frac{88.71 \text{ in}^3}{231 \text{ in}^3} = 0.384 \text{ gallons}$$

So for every foot of fluid travel 0.384 gallons will pass.

What is the flow rate in gpm at 4.3 ft/sec?

$0.384 \text{ gallons} \times 4.3 \text{ FPS} \times 60 \text{ sec (1 min)} = 99.1 \text{ gpm}$

Now that the volumetric flow rate is known, all that is needed is an output frequency to determine the K-factor.

Known values are:

Frequency	=	700 Hz (By measurement)
Flow Rate	=	99.1 gpm (By calculation)

$700 \text{ Hz} \times 60 \text{ sec} = 42{,}000 \text{ pulses per gallon}$

$$\text{K-factor} = \frac{42{,}000 \text{ pulses per min}}{99.1 \text{ gpm}} = 423.9 \text{ pulses per gallon}$$

MODBUS INTERFACE

A subset of the standard Modbus commands is implemented to provide access into the data and status of the ER-500 monitor. The following Modbus commands are implemented:

Command	Description
01	Read Coils
03	Read Holding Registers
05	Force Single Coil

Type	Bits	Bytes	Modbus Registers
Long Integer	32	4	2
Single Precision IEEE754	32	4	2

Modbus Register / Word Ordering

Each Modbus holding register represents a 16-bit integer value (2 bytes). The official Modbus standard defines Modbus as a 'big-endian' protocol where the most significant byte of a 16-bit value is sent before the least significant byte. For example, the 16-bit hex value of '1234' is transferred as '12''34'.

Beyond 16-bit values, the protocol itself does not specify how 32-bit (or larger) numbers that span over multiple registers should be handled. It is very common to transfer 32-bit values as pairs of two consecutive 16-bit registers in little-endian word order. For example, the 32-bit hex value of '12345678' is transferred as '56''78''12''34'. Notice the Register Bytes are still sent in big-endian order per the Modbus protocol, but the Registers are sent in little-endian order.

Other manufacturers store and transfer the Modbus Registers in big-endian word order. For example, the 32-bit hex value of '12345678' is transferred as '12''34''56''78'. It does not matter which order the words are sent, as long as the receiving device knows which way to expect it. Since word order is a common problem between devices, many Modbus master devices have a configuration setting for interpreting data (over multiple registers) as 'little-endian' or 'big-endian' word order. This is also referred to as swapped or word swapped values and allows the master device to work with slave devices from different manufacturers.

If the endianness is not a configurable option within the Modbus master device, it's important to make sure it matches the slave endianess for proper data interpretation. The ER-500 monitor actually provides two Modbus register maps to accommodate both formats. This is useful in applications where the Modbus master cannot be configured for endianness.

Register Mappings

Data Component Name	MODBUS Registers		Available Units
	Long Integer Format	Single Precision Floating Point Format	
Spare	40100…40101	40200…40201	—
Flow Rate	40102…40103	40202…40203	Gallons, Liters, MGallons, Cubic Feet, Cubic Meters, Acre Feet, Oil Barrel, Liquid Barrel, Feet, Meters, Lb, Kg, BTU, MBTU, MMBTU, TON Per Second, Minute, Hour, Day
Spare	40104…40105	40204…40205	
Positive Totalizer	40106…40107	40206…40207	
Grand Total Totalizer	40108…40109	40208…40209	
Battery Voltage	40110…40111	40210…40211	x.xx
Spare	40112…40113	40212…40213	—

For reference: If the ER-500 totalizer = 12345678 hex
Register 40106 would contain 5678 hex (Word Low)
Register 40107 would contain 1234 hex (Word High)

Data Component Name	MODBUS Registers		Available Units
	Long Integer Format	Single Precision Floating Point Format	
Spare	40600…40601	40700…40701	–
Flow Rate	40602…40603	40702…40703	Gallons, Liters, MGallons, Cubic Feet, Cubic Meters, Acre Feet, Oil Barrel, Liquid Barrel, Feet, Meters, Lb, Kg, BTU, MBTU, MMBTU, TON Per Second, Minute, Hour, Day
Spare	40604…40605	40704…40705	
Positive Totalizer	40606…40607	40706…40707	
Grand Total Totalizer	40608…40609	40708…40709	
Battery Voltage	40610…40611	40710…40711	x.xx
Spare	40612…40613	40712…40713	

For reference: If the ER-500 totalizer = 12345678 hex
Register 40606 would contain 1234 hex (Word High)
Register 40607 would contain 5678 hex (Word Low)

Modbus Coil Description	Modbus Coil	Notes
Reset Running Totalizer	1	Forcing this coil ON will reset the running totalizer. After reset, the coil automatically returns to the OFF state.
Reset Grand Totalizer	2	Forcing this coil ON will reset both the running totalizer and the grand totalizer. After reset, the coil automatically returns to the OFF state.
—	3…8	Spares
Alarm Setpoint 1	9	0 = Setpoint OFF, 1 = Setpoint ON
Alarm Setpoint 2	10	0 = Setpoint OFF, 1 = Setpoint ON
—	11…16	Spares

Opcode 01 - Read Coil Status

This opcode returns the state of the alarm coils. The following Coils are defined:

Coil #	Description
9	Alarm Setpoint 1
10	Alarm Setpoint 2
11 and up	Spare

Command: <addr><01><00><08><00><02><crc-16>
Reply: <addr><01><01><0x><crc-16>

Opcode 03 - Read Holding Registers

This opcode returns the input holding registers, such as flow rate or totalizer.

NOTE: Each value must be requested individually. Return of a block of registers is not implemented at this time.

Example requesting flow rate in floating point format.

Command: <addr><03><00><C9><00><02><crc-16>
Reply: <addr><03><02><data><data><crc-16>

Opcode 05 - Force Single Coil

This opcode sets the state of a single coil (digital output). The following Coil Registers are defined:

Coil #	Description
1	Reset Totalizer
2	Grand Totals
3 and up	Spares

The transition of coil from 0 to 1 will initiate function. This bit is auto reset to 0, so there is no need to set it to 0 after a totalizer reset command.

Command: <addr><05><00><00><FF><00><crc-16>
Reply: <addr><05><00><00><FF><00><crc-16>

BATTERY REPLACEMENT

Battery powered monitors use a single 3.6V DC D size, lithium battery. When replacement is necessary, use a clean fresh battery to ensure continued trouble-free operation.

Replacement Batteries	
Manufacturer	**Part Number**
Badger Meter	B300028
Xeno	S11-0205-10-03
Tadiran	TL-5930/F

2. Unscrew the four captive screws on the front panel to gain access to the battery (see *Figure 17*).

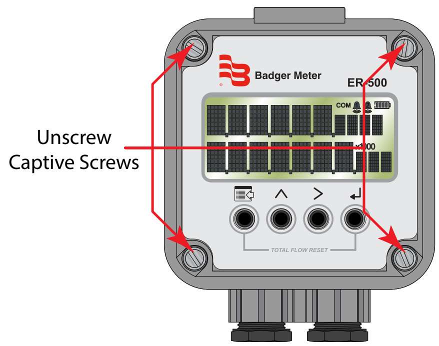


Figure 17: Opening the

3. Press the tab on the battery connector to release it from the circuit board (see *Figure 18*).

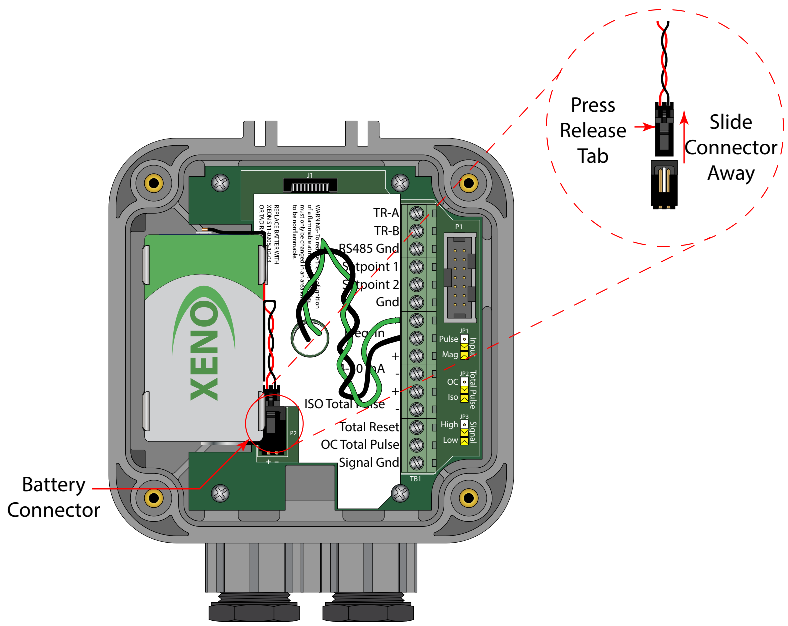


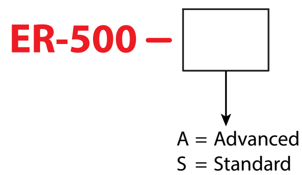
Figure 18: Battery connection release.

4. Remove the old battery and replace it with new one.
5. Re-fasten the front panel screws.

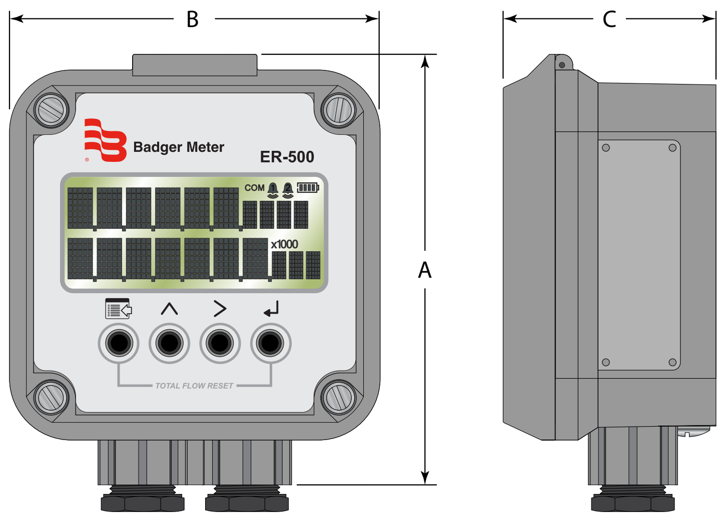
SPECIFICATIONS

LCD	Simultaneously shows Rate and Total 5 x 7 Dot matrix LCD, STN fluid 6 Digit rate, 0.5 inch (12.7 mm) numeric 7 Digit total, 0.5 inch (12.7 mm) numeric Engineering unit labels 0.34 inch (8.6 mm)				
Annunciators	Alarm 1(1), Alarm 2 (2), Battery Level (), RS485 Communications (COM)				
Power	Battery	3.6V DC lithium "D Cell" gives up to 6 years of service life			
	Loop	4…20 mA, two wire, 25 mA limit, reverse polarity protected, 7 V DC loop loss Auto switching between internal battery and external loop power; includes isolation between loop power and other I/O			
Inputs	Magnetic Pickup	Frequency Range	1…3500 Hz		
		Frequency Accuracy	±0.1%		
		Over Voltage Protection	28V DC		
		Trigger Sensitivity	30 mVp-p (High) or 60 mVp-p (Low) - (selected by circuit board jumper)		
	Amplified Pulse	Direct connection to amplified signal (pre-amp output from sensor)			
Outputs	Analog 4…20 mA	4…20 mA, two-wire current loop 25 mA current limit			
	Totalizing Pulse	One pulse for each Least Significant Digit (LSD) increment of the totalizer			
		Pulse Type (selected by circuit board jumper)	Opto-isolated (Iso) open collector transistor Non-isolated open drain FET		
		Maximum Voltage	28V DC		
		Maximum Current Capacity	100 mA		
		Maximum Output Frequency	16 Hz		
		Pulse Width	30 mS fixed		
	Status Alarms (Advanced Only)	Type	Open collector transistor Adjustable flow rate with programmable dead band and phase.		
		Maximum Voltage	28V DC		
		Maximum Current	100 mA		
		Pull-Up Resistor:	External required (2.2 K ohm minimum, 10 K ohm maximum)		
	Modbus (Advanced Only)	Modbus RTU over RS485, 127 addressable units / 2-wire network, 9600 baud, long integer and single precision IEEE754 formats; retrieve: flow rate, job totalizer, grand totalizer, alarm status and battery level; write: reset job totalizer, reset grand totalizer			
	Data Configuration and Protection	Two 4-digit user selectable passwords; level one password enables Job Total reset only, level two password enables all configuration and totalizer reset functions (Not Applicable on solar powered units)			
Safety Certifications	Class I Division 1, Groups C, D; Class II, Division 1 Groups E, F, G; Class III for US and Canada. Complies with UL 913 and CSA C22.2 No. 157-92				
Entity Parameters	4…20mA Loop	V_{max} = 28V DC	I_{max} = 26 mA	C_i = 0.5 µF	L_i = 0 mH
	Pulse Output	V_{max} = 28V DC	I_{max} = 100 mA	C_i = 0 µF	L_i = 0 mH
	Reset Input	V_{max} = 5V DC	I_{max} = 5 mA	C_i = 0 µF	L_i = 0 mH
	RS485	V_{max} = 10V DC	I_{max} = 60 mA	C_i = 0 µF	L_i = 0 mH
	Sensor Input	V_{oc} = 2.5 V	I_{sc} = 1.8 mA	C = 1.5 µF	L_a = 1.65 H
EMC	2004/108/EC				
Accuracy	0.05%				
Response Time	1…100 seconds response to a step change input, user adjustable				
Environmental Limits	–22…158° F (–30…70° C); 0…90% humidity, non-condensing;				
Materials	Polycarbonate, stainless steel, polyurethane, thermoplastic elastomer, acrylic				
Enclosure Ratings	NEMA 4X/IP 66				

MODEL NUMBERS



DIMENSIONS



A	B	C
5.0 in. (127.0 mm)	4.5 in. (114.3 mm)	2.6 in. (66.0 mm)

TROUBLESHOOTING GUIDE

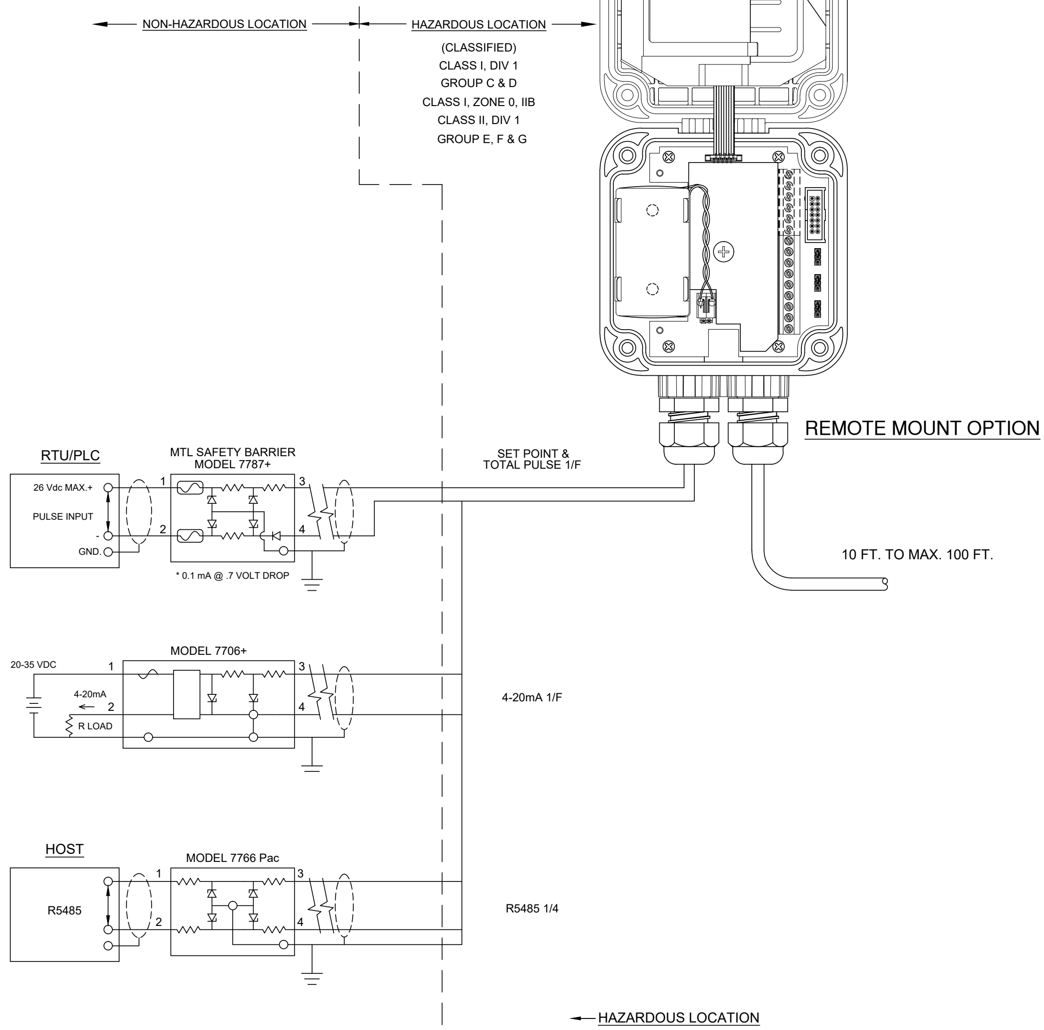
Trouble		Remedy
No LCD Display	Battery	Check battery voltage. Should be 3.6 V DC. If the input is 3.4V DC or lower, replace the battery.
	Loop power	Check 4…20 mA input. Voltage must be within the minimum and maximum supply voltage and capable of supplying enough current to run the display. The input voltage is checked "across" or in parallel with the 4…20 mA terminals and current is checked with the ammeter in series with the 4…20 mA output.
No Rate or Total Displayed		Check connection from meter's transmitter to display input terminals. Check turbine meter rotor for debris. Rotor should spin freely. Check programming of flow monitor.
Flow Rate Display Interprets Reading Constantly		This is usually an indication of external noise. Keep all AC wires separate from DC wires. Check for large motors close to the meter pickup. Check for radio antenna in close proximity.
Flow Rate Indication Erratic		This usually indicates a weak signal. Replace pickup and/or check all connections. Check for correct factor. Check that the ILR transmitters meter size selection switch is set to the correct size.

CONTROL DRAWING

DRAWING # B300019

TABLE 2

	4-20mA Loop	Pulse Output	Reset Input	RS485	Turbine Input
V Max	28 Vdc	28 Vdc	5 Vdc	10 Vdc	Voc = 3.5V
I Max	26mA	100mA	5mA	60mA	Isc = 3.6mA
Ci	0.5µF	0.0µF	0.0µF	0.0µF	Ca = 15µF
Li	0.0mH	0.0mH	0.0mH	0.0mH	La = 1.65H



NOTES ON BARRIERS:

1. SELECTED BARRIERS MUST BE CERTIFIED AS INTRINSICALLY SAFE FOR THE APPLICATION AND HAVE Voc NOT EXCEEDING Vmax AND Isc NOT EXCEEDING Imax CAPACITIANCE VALUE SHALL BE AS SHOWN IN TABLE 1.
2. INTERCONNECTING CABLE CAPACITANCE AND INDUCTANCE, PLUS THE CAPACITANCE AND INDUCTANCE OF THE INTRINSICALLY SAFE EQUIPMENT, MUST BE LESS THAN OR EQUAL TO THE CAPACITANCE
3. MAY BE IN DIVISION 2 LOCATION IF SO APPROVED
4. BARRIERS MUST BE INSTALLED IN ACCORDANCE WITH BARRIER MANUFACTURER'S CONTROL DRAWING, CANADIAN ELECTRICAL CODE PART 1, SEC. 18 AND APPENDIX F, ARTICLE 500 OF THE NEC, OR OTHER LOCAL CODES.
5. WHEN SELECTING CABLE FOR CONNECTION TO TURBINE METER, USE CABLE WITH THE FOLLOWING

CONFIDENTIAL

ALL PROPRIETARY RIGHTS IN THE SUBJECT MATTER SHOWN ON THIS DRAWING ARE EXCLUSIVE PROPERTY OF BADGER METER.

VENDOR NOTE:

IMPORTED ITEMS REQUIRE COUNTRY OF ORIGIN MARKING IN COMPLIANCE WITH 19 U.S.C. 1304

UNLESS OTHERWISE SPECIFIED

ALL DIMENSIONS ARE IN INCHES [MM]

DRAWING AND TOLERANCES PER ANSI Y14.1-2004 & Y14.5-2009

THIS DRAWING TO BE USED WITH CAD MODEL, WHEN SUPPLIED BY BADGER METER, FOR COMPLETE PRODUCT DEFINITION PER ANSI Y14.41-2003

TOLERANCE ON 4 PLACE DIMENSIONS	±.0025 [0.0635]
TOLERANCE ON 3 PLACE DIMENSIONS	± .005 [.127]
TOLERANCE ON 2 PLACE DIMENSIONS	±.01 [.25]
TOLERANCE ON ANGULAR DIMENSIONS	± 0.5°

REMOVE ALL BURRS R.005 MAX OR .005 x 45°

MACHINED SURFACES FINISH - 125 MICROINCHES OR BETTER

Figure 19: Control drawing

NOTES ON FLOW SENSOR

1. INTERCONNECTING CABLE CAPACITANCE AND INDUCTANCE, PLUS THE CAPACITANCE AND INDUCTANCE OF THE MAGNETIC PICKUP, MUST BE LESS THAN OR EQUAL TO THE CAPACITANCE(Ca) AND THE INDUCTANCE(La) "TURBINE INPUT" ENTITY PARAMETERS MARKED ON THE B3000 MONITOR AND TABLE 2.

NOTES ON CABLE ENTRY

1. ALL CABLE ENTRIES INTO THE ENCLOSURE MUST BE BROUGHT THROUGH SUITABLY SIZED UL & CSA CERTIFIED LIQUID TIGHT STRAIGHT THRU FITTINGS

NOTES ON CONTROL EQUIPMENT

1. CONTROL EQUIPMENT MUST NOT USE OR GENERATE MORE THAN 250 V, WITH RESPECT TO EARTH.

TABLE 1:

IS EQUIPMENT		BARRIER
Vmax	$\geq$	Voc
Imax	$\geq$	Isc
Ci + Cc	$\leq$	Ca
Li + Lc	$\leq$	La

ADVANCE PRINT

ER# 19828

ENG. DN DATE: 3/30/16

ISSUE	CHANGE	BY	DATE
	19828	SB	3/30/16

Badger Meter

PART #	B300019
REV	1
DRAWN	S. BENOIT 3/30/16
CHECKED	
APPROVED	
PART NAME	INSTALLATION DRAWING FOR B3000 (ER-500) REMOTE MOUNT MONITOR
MATERIAL	SEE ABOVE
PRODUCT LINE	BLANCETT
EST WEIGHT	-
VOLUME	-
SCALE	NTS
SHEET	1 OF 1
SHEET SIZE	D
DRAWING #	B300019
ISSUE	A1

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