Sonic Driver

Made in Britain

FIXED-UFM Ultrasonic Flowmeter

Operating Instructions

Version 4.0

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Contents

1.0 Introduction

Congratulations on choosing the Sonic Driver Fixed-UFM wall mounted clamp-on ultrasonic flowmeter, figure (1).

Figure (1) The Sonic Driver Fixed-UFM.

The ultrasonic flowmeter (UFM) uses advanced Digital Signal Processing (DSP) and transit time measurement techniques (Sonic Driver^{TM}) to make accurate and reliable clamp-on ultrasonic flow velocity measurements.

Using information about the installation, entered by the user, using the meters intuitive and easy to us menu driven User Interface (UI) the UFM can display;

- Flow velocity
- Volumetric flow rate
- Mass flow rate
- Heat quantity flow rate

Heat calculations can be made to the method specified in EN1434-1 section 8 and appendix A.

The UFM comes in 3 different versions;

- Standard - outer pipe diameter ranged 10.0 to 115.0 mm
- Medium - outer pipe diameter ranged 115.0 to 225.0 mm
- Large - outer pipe diameter ranged 225.0 to 6500.0 mm

1.1 General Precautions

The content of this manual has been carefully checked and is believed to be accurate.

Sonic Driver Ltd assumes no responsibility for any inaccuracies that may be contained in this manual.

In no event will Sonic Driver be liable for direct, indirect, special, incidental or consequential damages resulting from any defect or omission in this manual, even if we are advised of the possibility of such damages.

Sonic Driver Ltd reserves the right to make improvements to its manuals, instructions and products at any time, without notice or obligation. The latest revisions may be found on the company web site, www.sonic-driver.com

The UFM is a precision measuring instrument and should be handled and operated with care;

- Before operating the UFM for the first time read the installation manual and operating instruction fully.
- Only use the UFM in the way and for the purpose that it is intended.
- Do not subject the UFM to bumps and shocks such as caused by dropping the UFM.
- Keep the UFM and its transducers and probes clean.
- Only use the UFM within its ambient temperature and stated level of Ingress Protection.
- Avoid excessive stress and bending of transducer cables and connectors.
- Avoid striking the clear display window and keypad with sharp objects.

2.0 Keypad Functionality

The UFM keypad offers several dual operation FUNCTION KEYS for quick setup and display. Press any of the FUNCTION KEYS to go to the desired menu or display instantly. Note however that depending on what the user is attempting to do the focus of certain keys will change.

When the user is navigating the UI and selecting a Menu screen;

1	Jump to MAIN MENU, the Quick Start option will be highlighted.
2	Jump to show Sensor Positioning screen, the user is prompted to select a Transducer Type.
3	Jump to show ATA/ETA % diagnostic.
4	Jump to show Flow Rate and Net Total.
5	Jump to show flow velocity, flow rate, net, positive and negative flow totaliser.
6	Jump to show Reynolds Number, flow profile correction K Factor, Raw Flow velocity and Corrected flow velocity.
U	Scroll up through Menu items.
7	Jump to show Energy Rate and Net Total.
8	Jump to show energy rate, net, positive and negative energy totaliser.
9	Jump to show Compensation, Inlet and Outlet temperature.
ENT	Step forward to selected Menu.
.	Jump to show time-based diagnostics.
0	Jump to show signal-based diagnostics.
ESC	Step back to previous Menu (when at MAIN MENU jump to Measurement screen).
D	Scroll down through Menu items.

When the meter is in measurement mode and measuring the keypad keys have the following functions;

1	Jump to MAIN MENU, the Quick Start option will be highlighted.
2	Jump to show Sensor Positioning screen, the user is prompted to select a Transducer Type.
3	Jump to show ATA/ETA % diagnostic.
4	Jump to show Flow Rate and Net Total.
5	Jump to show flow velocity, flow rate, net, positive and negative flow totaliser.
6	Jump to show Reynolds Number, flow profile correction K Factor, Raw Flow velocity and Corrected flow velocity.
U	Display contrast up.
7	Jump to show Energy Rate and Net Total.
8	Jump to show energy rate, net, positive and negative energy totaliser.
9	Jump to show Compensation, Inlet and Outlet temperature.
ENT	Step through all available display screens.
.	Jump to show time-based diagnostics.
0	Jump to show signal-based diagnostics.
ESC	Jump to UI, show last menu accessed.
D	Display contrast down.

ENT steps through the screens listed above and also additional diagnostic screens showing log memory remaining, control unit and inlet and outlet temperatures, heat calculations, etc..

Parameter entry

When the user is editing a parameter and the parameter editing cursor starts to flash the keypad keys change function to become alphanumeric inputs;

1	Enter "1".
2	Enter "2".
3	Enter "3".
4	Enter "4".
5	Enter "5".
6	Enter "6".
U	Delete a character or scroll up though available parameter options in a list.
7	Enter "7".
8	Enter "8".
9	Enter "9".
ENT	Accept and Save changes and return to last Menu screen.
.	Enter ".".
0	Enter "0".
ESC	Return to last Menu screen, discard any changes.
D	Enter "–" symbol or scroll down though available parameter options in a list**.**

3.0 FUNCTION KEY Functions

The keypad has a number of FUNCTION KEYS, which allow the user to instantly access functions;

<1> Quick Start

This key jumps to the Main Menu with the Quick Start option highlighted.

Press ENT to start the Quick Start sequence or navigate the UI in the usual way.

<2> Transducer Positioning

This key gives access to a function which calculates the recommended transducer spacing and displays diagnostics to aid transducer mounting and allows coupling optimization.

After entering the required Quick Start parameters, the spacing between the ends of the 2 transducers is calculated and displayed. Check the value displayed and space the transducers accordingly.

If the Set Zero calibration function is enabled a zero flow calibration will also be made. It is vitally important to ensure that there is zero flow during this procedure. If the UFM suspects that there is flow in the pipe then a visual warning is given.

When the process is complete the user is returned to the UI.

<3> ATA/ETA %

This key gives access to a display of transit time ratio shown as a percentage value. This is a measure of the ratio of the measured transit time to that which is expected given the parameters entered by the user during Quick Start. It indicates if the transducer mounting and spacing is accurate. The normal transit time ratio should be 100 ± 3 % if the installation is correct.

It is acceptable to have to move one of the transducers up to ± 5 mm to achieve a figure of 100 %. If more movement is necessary then one of the pipe parameters is probably incorrect. This is most likely to be the value entered for pipe wall thickness as this is often taken from tables or it is an estimated value.

<4> Flow Rate and Net Total

This key gives access to a display showing;

- Flow rate
- Net flow totaliser

<5> Flow Velocity, Rate and Totals

This key gives access to a display showing;

- Flow velocity
- Flow rate
- Net flow totaliser
- Positive flow totaliser

- Negative flow totaliser

Net total is simply the sum of the positive and negative flow totals.

<6> Flow Profile

This key gives access to a display showing;

- Reynolds Number
- Flow profile correction K factor
- Raw flow velocity
- Rolling average flow velocity
- Corrected flow velocity

The raw flow velocity is displayed without averaging and uncompensated for flow profile.

Rolling average flow velocity is raw flow velocity with average and flow profile compensation applied.

Corrected flow velocity is rolling average flow velocity with zero flow cut off applied.

<7> Energy Rate and Net Total

This key gives access to a display showing;

- Energy rate
- Net energy totaliser

<8> Energy Rate and Totals

This key gives access to a display showing;

- Energy rate
- Net energy totaliser
- Positive energy totaliser
- Negative energy totaliser

<9> Temperature

This key gives access to a display showing;

- Control Unit temperature
- Compensation (fluid) temperature
- Pipe inlet temperature
- Pipe outlet temperature

The fluid temperature is used for compensation of; speed of sound, density, viscosity and specific heat capacity.

Depending on the method being used to make heat calculations the display also shows enthalpy/density, SHC values.

<.> Time Based Diagnostics

This display shows diagnostics relating to the timing measurements being made by the UFM.

- Delta Time
- Transit Time
- Path Time
- dT Offset
- SOS expected and measured

The absolute upstream transit time through the fluid in the pipe and the absolute downstream transit time through the fluid in the pipe are usually of the order of hundreds of microseconds. They are very nearly identical. For this reason Transit Time is simply displaying the absolute upstream transit time through the fluid in the pipe.

Delta Time is the difference in time between the two absolute transit times through the fluid. Delta Time is of the order of tens of nanoseconds because the absolute upstream and downstream times are so close together in value.

These values can help indicate the accuracy and condition of the installation. The measurement calculations in the UFM are based upon these two values.

Therefore, when transit time difference fluctuates widely, the flow and velocities fluctuate accordingly. This is usually accompanied by a signal strength and/or signal to noise ratio (SNR) that is too low and varying. This may be the result of poor pipe installation conditions, inadequate transducer installation, or incorrect parameter input. Generally, fluctuations should be less than ± 20 %.

Path Time is the absolute upstream transit time through the entire ultrasonic path. This is different to the absolute upstream transit time in the fluid as it includes time spent traversing the transducer wedges, pipe and lining (if applicable). It is useful for fault finding with an oscilloscope as it is referenced to a trigger signal available at a test point on the UFM PCB.

dT Offset is the offset value currently being used by the zero tracking function. This is usually in the range ± 2.5 ns.

SOS displays the expected and measured speed of sound in the fluid. It is used to calculate the value of ATA/ETA %. A large difference (typically greater than ± 3 %) can indicate something wrong in the installation.

<0> Signal Based Diagnostics

This key gives access to a display showing diagnostics related to the signal strength and SNR of the received sonic signal;

- Signal
- SNR
- Noise
- ATA/ETA
- Gain

Signal strength indicates the detected strength of the sonic signal in decibels (dB). Signal strength is indicated by numbers from typically -25.0 to +55.0.

Normally, the stronger the signal strength detected the better and more reliable the flow measurement is, as well as the more stable the measurement value obtained.

Adjust the transducer positioning to the best position, within limits and check to ensure that enough sonic coupling compound is applied during installation to obtain the maximum signal strength.

The UFM normally requires signal strength over 0.0 dB to measure reliably. If the signal strength detected is too low (is zero or negative), the transducer installation position and the transducer mounting spacing should be adjusted and the pipe should be inspected. If necessary, change the mounting position and/or method.

SNR indicates the quality of the sonic signal detected. SNR is indicated by numbers from typically 1.0 to 99.0, in dB.

1.0 represents the minimum SNR whilst 99.0 represents the maximum.

Normally, the transducer position should be adjusted and coupling compound application should be checked until the SNR detected is as large as possible.

The UFM normally requires SNR over 12.0 dB to measure reliably.

Noise indicates the level of extraneous sonic and electrical noise being detected in dB. Noise is indicated by numbers from typically -25.0 to +55.0.

The UFM normally requires noise strength below +10.0 dB to measure reliably.

Gain indicates the amount of electronic gain being used by the UFM receiver amplifier. Gain is indicated by numbers from typically 0.0 to 81.0, in dB.

0.0 represents the minimum gain whilst 81.0 represents the maximum.

Old pipes, attenuating pipes, corrosion, attenuating fluids, etc. can require the UFM to automatically turn up its gain.

The UFM normally operates with a gain typically around 30.0 to 60.0 dB.

ATA/ETA % or transit time ratio indicates if the transducer mounting spacing is accurate. The normal transit time ratio should be 100 ± 3 % if the installation is correct.

The Installation Manual that accompanies these Operating Instructions gives more details regarding mounting, coupling and spacing the transducers correctly.

4.0 Powering On

To power on the UFM simply apply AC or DC power as appropriate to the model, see the installation manual for details of mounting and wiring the UFM and important safety information.

As soon as the UFM is switched on a self-diagnostic program will start.

If an error is detected an error message will be displayed prompting user action. If the error persists contact customer support.

See relevant sections on Input/Output and Datalogger below for more detail of what tests are carried out.

Error codes and their meanings can be found in the Diagnostics Menu.

5.0 User Interface (UI)

The Main Menu allows the user to select a group of parameters to edit or a meter function;

- Quick Start
- Installation
- System Settings
- Diagnostics
- Input/Output
- RS232/USB
- Datalogger
- Batching
- Manual Totaliser
- Phase Detection
- Heat Metering

5.1 Quick Start Function

The Quick Start function takes the user through the minimum sequence of parameters needed to get the UFM measuring reliably and accurately;

- Pipe Outer Diameter
- Pipe Wall Thickness
- Pipe Material
- Liner Material
- Fluid Type
- Fluid Temperature
- Transducer Type
- Transducer Mounting

Each parameter is described below in the relevant section.

5.2 Installation Menu

The Installation Menu allows the user to edit parameters specific to the physical installation of the UFM on a pipe;

- Pipe Settings
- Liner Settings
- Fluid Settings
- Transducer Settings
- Calibration Settings
- Display Units
- Totaliser Settings
- Factory Defaults

These parameters represent an extended set of parameters needed to get the UFM measuring and displaying values, above and beyond the very basic parameter set used by the Quick Start sequence**.**

5.2.1 Pipe Menu

This menu allows the user to change pipe settings. A test is made to check that the change has not resulted in a Closed Pipe.

5.2.1.1 Pipe Outer Diameter

The user is prompted to enter a value for the pipe outer diameter. The UFM comes in 3 different versions;

- Standard - Allowed values are ranged 10.0 to 115.0 mm
- Medium - Allowed values are ranged 115.0 to 225.0 mm
- Large - Allowed values are ranged 225.0 to 6500.0 mm

For each size the default is 56.0 mm.

5.2.1.2 Pipe Wall Thickness

The user is prompted to enter a value for the pipe wall thickness. Allowed values are ranged 0.5 to 100.0 mm, default 1.8 mm.

5.2.1.3 Pipe Material

The user can select the pipe material from a list;

- Carbon Steel
- Stainless 304
- Stainless 316
- Cast Iron
- Ductile Iron
- Copper
- PVC **(Default)**
- Lead
- Nylon
- PE
- Aluminium
- Asbestos
- Fibre Glass
- Other

If Other is selected then the user is prompted to enter the transverse (shear) speed of sound in the pipe material, see below. Otherwise the transverse speed of sound in the pipe material is read from a database held in the UFM.

5.2.1.4 Pipe Roughness

The user is prompted to enter a value for the peak/trough height of the roughness on the inside surface of the pipe. Allowed values are ranged 0.001 to 10.000 mm, default 0.010 mm.

If a liner material is selected then this roughness is automatically transposed and applied to the inner surface of the lining.

This value is used in flow profile correction calculations.

5.2.1.5 Pipe Sound Velocity

Appearance of this parameter is context driven. If the Pipe Material is entered as Other then the user is prompted to enter a pipe transverse sound velocity.

The user is prompted to enter the transverse speed of sound in the pipe. Allowed values are ranged 500 to 7000 m/s, default 1060 m/s (PVC).

5.2.2 Liner Menu

This menu allows the user to change pipe lining settings.

5.2.2.1 Liner Material

The user can select a pipe liner material from a list;

- None **(Default)**
- Cement
- Epoxy
- Glass
- PP
- Teflon
- Rubber
- Other

The list allows no liner (None) to be selected.

5.2.2.2 Liner Sound Velocity

Appearance of this parameter is context driven. If the user selected Other from the list of liner materials then the user is prompted to enter the transverse speed of sound in the liner material. Otherwise the speed of sound in the liner material is read from a database held in the UFM.

Allowed values are ranged 500 to 7000 m/s, default 0 m/s (None).

5.2.2.3 Liner Thickness

Appearance of this parameter is context driven. If the user selected a liner then the user is prompted for the thickness of the liner. Allowed values are ranged 0.5 to 100.0 mm, default 0.0 mm (None).

5.2.3 Fluid Menu

This menu allows the user to change fluid settings.

5.2.3.1 Fluid Type

The user can select the fluid in the pipe from a list;

- Water **(Default)**
- Sea Water
- Kerosene
- Petrol
- Fuel Oil
- Crude Oil
- Freon R134a
- Freon R22
- Diesel Oil
- Castor Oil
- F-76 Fuel Oil
- Novec 1230
- Glycol/Water
- Alcohol
- Other

If the user selected Other from the list of fluid types then the user is prompted to enter various context driven parameters, see below.

5.2.3.2 Fluid Temperature

The user is prompted to enter the temperature of the fluid in the pipe. Allowed values are ranged -20 to +150 degC, default 18 degC.

If an optional plug-in PT100 IO module is fitted and its Mode is selected as Inlet+Compensation, Outlet+Compensation or Compensation then the dynamic value at the PT100 is overwritten into this parameter during measurement.

Changing Fluid Temperature causes Fluid Sound Velocity, Fluid Kinematic Viscosity, Fluid Density and Fluid Specific Heat Capacity to be recalculated.

5.2.3.3 Fluid Sound Velocity

Appearance of this parameter is context driven. If the user selected Other from the list of fluid types then the user is prompted to enter the longitudinal (NOTE… not transverse) speed of sound in the fluid. Otherwise the longitudinal speed of sound in the fluid is read from a database held in the UFM.

The user is prompted to enter the longitudinal speed of sound in the fluid. Allowed values are ranged 50 to 4000 m/s, default 1475.46 m/s (Water at 18 degC).

5.2.3.4 Fluid Kinematic Viscosity

Appearance of this parameter is context driven. If the user selected Other from the list of fluid types then the user is prompted to enter the kinematic viscosity of the fluid. Otherwise the kinematic viscosity of the fluid is read from a database held in the UFM.

The user is prompted to enter the kinematic viscosity of the fluid. Allowed values are ranged 0.001 to 40000 cST, default 1.08 cST (Water at 18 degC).

5.2.3.5 Fluid Density

Appearance of this parameter is context driven. If the user selected Other from the list of fluid types then the user is prompted to enter the density of the fluid. Otherwise the density of the fluid is read from a database held in the UFM.

The user is prompted to enter the density of the fluid. Allowed values are ranged 50 to 3000 kg/m3, default 998.52 kg/m3 (Water at 18 degC).

5.2.4 Transducer Menu

This menu allows the user to change transducer settings.

5.2.4.1 Transducer Type

The user is prompted to select the type of sensors mounted on the pipe from a list;

- DS05
- DS10
- DS20
- DS40
- DM10 **(Default)**
- DM20
- DN40
- Flow Other

DM sensors are Sonic Driver standard PEEK/stainless steel design. DN sensors are Sonic Driver small pipe design. DS sensors are Sonic Driver large pipe design.

If Flow Other is selected then the user will be prompted to enter detailed transducer specific information, see Appendix A.

The ability to select Flow Other is intended for use when using the UFM with special sensors supplied by Sonic Driver.

5.2.4.2 Transducer Mounting

The user is prompted to select the sound path in the pipe from a list;

- Auto
- Z
- V
- N
- W
- 5
- 6 **(Default)**
- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14

Selecting Auto means that the UFM determines for itself which sound path to use.

Ideally choose a number of passes that results in a path length in the fluid of 100 mm or greater.

- Z is 1 pass, most common on large diameter pipes.

- V is 2 passes, the most commonly used method, simplest to install as both sensors are on the same side of the pipe.
- N is 3 passes, used on small diameter pipes.
- W is 4 passes, used on the lowest diameter pipes.
- 5 to 13 and 14, etc.

It may be that on small diameter pipes then the recommended transducer spacing at 14 passes is not sufficient to allow the transducers to be coupled on the same side of the pipe, an even number of passes as they touch. In this case it is unavoidable to couple the transducers on opposite sides of the pipe using an odd number of passes, for example 11 or 13 passes.

5.2.5 Calibration Settings Menu

This menu allows the user to change calibration and calculation settings.

5.2.5.1 Low Flow Cutoff

If the flow velocity falls below the low flow cutoff value, the measured flow velocity and calculated flow rate indication is driven to zero. This function can prevent the flow meter from reading flow after a pump is shut down but there is still circulating liquid creating movement in the pipe, which will result in a totaling error.

Generally, 0.025 m/s is recommended as the low flow cutoff point. The low flow cutoff value has no relation to the measurement results once the velocity increases over the low flow cutoff value.

The user is prompted to enter a value in m/s below which the meter reports flow as zero. Allowed values are ranged 0.000 to 1.000 m/s, default 0.025 m/s.

Note. This absolute value is applied to both positive and negative flow as a +/- band either side of zero.

5.2.5.2 High Flow Cutoff

If the flow velocity goes above the high flow cutoff value, the measured flow velocity and calculated flow rate indication is held at the high flow cutoff values. This function is rarely used.

The user is prompted to enter a value in m/s above which the meter reports maximum flow. Allowed values are ranged 0.1 to 30.0 m/s, default 30.0 m/s.

Note. This absolute value is applied to both positive and negative flow as a +/- band either side of zero.

5.2.5.3 Corrected Flow

The user is prompted to turn flow profile correction On/Off. By default flow profile correction is always turned on.

When turned On the meter measurements are corrected for flow profile using Reynolds Number and pipe wall internal roughness values.

The ability to turn flow profile correction Off is useful for benchmarking different types and makes of flowmeter where the sophistication of the manufacturers correction algorithms can lead to different results.

5.2.5.4 User Zero Offset

This user zero offset method is not commonly used. It is only suitable for experienced operators to set zero flow velocity in m/s under conditions when it is not preferable to use other methods. Enter the flow velocity value manually to add to the measured value to obtain the actual value.

The user is prompted to enter a measurement offset value in m/s. Allowed values are ranged -30.0 to +30.0 m/s, default 0.0 m/s.

5.2.5.5 User Scaling Factor

The manual PV scaling factor is used to modify the measurement results. The user can enter a numerical value other than “1.0” according to calibration results.

The user is prompted to enter a measurement scaling value. Allowed values are ranged 0.001 to 1000.0, default 1.000.

5.2.5.6 Set Zero Calibration

The user is prompted to turn zero calibration On/Off. A zero calibration can be made before the meter proceeds to measurement mode by using the transducer positioning FUNCTION KEY <2>. The user is prompted to couple and space the transducers in the normal way, but after this an additional optional automatic zero calibration is made.

By default Set Zero calibration is turned Off.

If Set Zero calibration is turned On then a zero flow calibration is made.

It is important that the SNR and other signal diagnostics are within tolerance during this process. Until the meter is satisfied the display will show a "Waiting" warning message. Only when happy will it start to average up.

NOTE. PIPE MUST BE FULL AND FLOW MUST BE ZERO.

The meter will make 19 averaged measurements and determine any offset values. Allow the zero calibration process to finish or press [ENT] to finish early.

If a zero flow delta time difference of greater then +/- 2.5 ns is measured then the user is warned to check that there is zero flow in the pipe.

5.2.5.7 Zero Tracking

When the measured delta time falls below a lower limit then the flow being measured is assumed by the UFM to be zero.

The user can turn a tracking algorithm On/Off so that such a small offset value is tracked/trended to zero.

By default zero tracking is always turned On.

At extremely low flows the meter can mistakenly identify a flow from for example a real leak as an erroneous offset. To avoid the leak being tracked off turn zero tracking Off.

5.2.5.8 Tup Method

Only intended for expert users. The user can change the method used to calculate the upstream and downstream transit times.

5.2.5.9 Calculation Method

Only intended for expert users. The user can change the method used to calculate flow velocity.

5.2.5.10 Filter Method

Only intended for expert users. The user can change the method used to damp measurements, see section 5.2.6.7 Damping below.

The user is prompted to select between using the default RC time constant type damping and a more sophisticated Kalman filter.

Increasing the RC damping increases the stability. However, the measurement displayed can be slightly delayed due to over damping. Too much damping may also result in no response to real time fluctuations, especially when flow rate fluctuates wildly.

Therefore, damping should be kept at a minimum and increased just enough to reduce the fluctuation to an acceptable degree.

The Kalman filter responds more quickly to real large changes in flow than does the RC filter and is included as an option to avoid over damping.

5.2.6 Display Units Menu

This menu allows the user to change display unit settings.

5.2.6.1 Flow Rate Units

The user can select the units to be used for display of flow rate from a list;

- Cubic Meters (m3)
- Litres (1) **(Default)**
- USA Gallons (GAL)
- Imperial Gallons (Imp gal)
- Million Gallons (mg)
- Cubic Feet (cf)
- USA Barrels (US bbl)
- Imperial Barrels (Imp bbl)
- Oil Barrels (Oil bbl)
- Kilograms (kg)

Cubic Meters, Litres, USA Gallons, Imperial Gallons, Million Gallons, Cubic Feet, USA Barrels, Imperial Barrels and Oil Barrels are examples of volumetric flow rates.

Kilograms is a mass flow rate.

5.2.6.2 Flow Rate Time Units

The user can select the time units to be used for display of flow rate from a list;

- \second
- \minute **(Default)**
- \hour
- \day

5.2.6.3 Totaliser Units

The user can select the units to be used for display of flow totaliser (net, positive and negative) from a list;

- Cubic Meters (m3)
- Litres (1) **(Default)**
- USA Gallons (GAL)
- Imperial Gallons (Imp gal)
- Million Gallons (mg)
- Cubic Feet (cf)
- USA Barrels (US bbl)
- Imperial Barrels (Imp bbl)
- Oil Barrels (Oil bbl)
- Kilograms (kg)

The flow rate and flow totaliser units do not have to be the same.

5.2.6.4 Energy Units

The user can select the units to be used for display of both energy flow rate and energy totaliser (net, positive and negative) from a list;

- Giga Joule (GJ) **(Default)**
- Mega Joule (MJ)
- Kilo Joule (kJ)
- Kilo Calorie (kcal)
- Million BTU (MMBtu)
- BTU (BTU)
- American Tons (Tons)
- Metric Tonnes (Tonnes)
- Kilo Watt Hour (kWh)

The energy flow rate and energy totaliser units are the same.

5.2.6.5 Energy Time Units

The user can select the time units to be used for display of energy flow rate from a list;

- \second **(Default)**
- \minute
- \hour
- \day

5.2.6.6 Measurement Units

The user can select the units to be used for entry and display of certain values from a list;

- Metric **(Default)**
- Imperial

5.2.6.7 Damping

The user is prompted to enter a display damping or averaging time.

Allowed values are ranged 1 to 255 seconds, the default is 10 seconds.

The damping time can be adjusted to stabilise the flow value being displayed. Essentially, it is a type of signal filter applying an RC time constant.

Increasing the damping increases the stability. However, the measurement displayed can be slightly delayed due to over damping. Too much damping may also result in no response to real time fluctuations, especially when flow rate fluctuates wildly.

Therefore, damping should be kept at a minimum and increased just enough to reduce the fluctuation to an acceptable degree.

5.2.6.8 Decimal Places

The user can select how many Decimal Places (DP) flow velocity and flow rate measurement values are displayed to.

Allowed values are ranged 0 to 3 DP, the default is 2 DP.

5.2.7 Totalisers Menu

This menu allows the user to change totaliser settings.

5.2.7.1 Net Flow Totaliser

The user can turn a net flow totaliser On/Off so that net flow total is accumulated and displayed.

By default the net flow totaliser is turned Off.

5.2.7.2 Pos Flow Totaliser

The user can turn a positive flow totaliser On/Off so that positive flow total is accumulated and displayed.

By default the positive flow totaliser is turned Off.

5.2.7.3 Neg Flow Totaliser

The user can turn a negative flow totaliser On/Off so that negative flow total is accumulated and displayed.

By default the negative flow totaliser is turned Off.

5.2.7.4 Flow Totaliser Reset

The user can reset (zero) the flow totalisers.

Selecting YES will zero Net, Pos and Neg totalisers.

By default the flow totalisers are not reset.

5.2.7.5 Energy Totaliser

The user can turn a net energy totaliser On/Off so that net energy total is accumulated and displayed.

By default the net energy totaliser is turned Off.

5.2.7.6 Energy Totaliser Reset

The user can decide to reset (zero) the energy totaliser by selecting On/Off.

By default the net energy totaliser is not reset.

5.2.8 Factory Defaults

The user is prompted to reload factory defaults and return the meter to its factory configuration.

All parameters including Input/Output settings, RS232/USB, datalogger are reset to factory defaults.

Display contrast is reset to the factory default.

Tag and Identifier strings are reset to factory values.

Key code is not defaulted.

This does not affect datalogger memory, data is not erased.

All Totalisers are reset to zero.

By default the factory reset is not active.

5.3 System Settings Menu

This menu amongst other things allows the user to edit parameters specific to the UFM internal real time clock;

5.3.1 Date

Set the RTC date. The UI checks for illegal entry and leap years.

5.3.2 Time

Set the RTC time, uses 24-hour format. Only enter hours and minutes.

5.3.3 Date Format

Select date format from a list;

- dd/mm/yy **(Default)**
- mm/dd/yy
- yy/mm/dd

This format is used by the meter display, datalogger and RS232/USB to PC interface.

5.3.4 Language

The UFM can hold 2 language translations; at the moment English **(Default)** and American.

The user selects the working language from a list.

5.3.5 LCD Backlight

The user is prompted to turn the UFM LCD backlight on/off. By default the backlight is On.

5.3.6 Audio

The user is prompted to turn the UFM keypad audio on/off. By default the buzzer is On.

5.3.7 Tag

The user can enter a site Tag for the meter, this is an 8 character alpha numeric. It is used by the datalogger and the RS232/USB to PC interface.

5.3.8 Identifier

The user can enter a site Identifier for the meter, this is an 8 character alpha numeric. It is used by the datalogger and the RS232/USB to PC interface.

5.3.9 Key Code

The user can enter a 4 digit code to be used to lock/unlock the UFM, see below. The default is 1111.

5.3.10 System Lock

This option allows the user to decide whether to lock or unlock the UFM by selecting to turn the function On/Off.

Once the system is locked, any modification to the system is prohibited, but the UI is navigable.

Unlock the UFM by navigating to the System Lock menu and using the designated key code, see above.

5.3.11 Test

As soon as the UFM is switched on a self-diagnostic program will start.

As part of this diagnostic the UFM polls to determine integrity of datalogger memory and which if any optional plug-in IO modules are fitted.

The Test Menu allows the user to repeat the power on tests and also to further test the other major functions of the meter;

5.3.11.1 Installation

The user can turn a meter test mode On/Off. By default this is Off.

When turned on the meter simulates a slowly ramping flow velocity 0.... 10 m/s.

All subsequent volumetric, mass and heat quantity measurements are made using this velocity.

All IO modules, datalogger, display and RS232/USB to PC interface respond as programmed to these values.

NOTE: The user must remember to turn this test mode off in order to measure normally with real flow.

5.3.11.2 Display

The user is taken through a factory series of tests which fully exercise the meter LCD and its backlight.

5.3.11.3 Keypad

The user is taken through a factory series of tests which fully exercise the meter keypad and its audio indicator (Buzzer).

5.3.11.4 Memory

The user is taken through a factory series of tests which fully exercise the meter system FRAM memory and datalogger flash memory.

Note that the datalogger test will result in any logged data being erased, download important data before running this test.

The final datalogger memory test writes and reads back from all 16MB individually and can take up to 30 minutes. To stop this byte-to-byte test early press any key.

5.3.11.5 Peripherals

The user is taken through a factory series of tests which fully exercise the meter internal hardware;

- Temperature sensor
- RTC
- Optional plug-in IO modules

This test polls the IO modules that are fitted in the meter and populates the list of available modules. It is useful if the range of fitted modules changes.

In addition the test is automatically run and IO modules are polled at power on.

5.3.11.6 TOFM ID

This test polls the meter Time Of Flight Module (TOFM) and reads its hardware and software versions.

5.3.11.7 TOFM Key

This test polls and reads a transducer memory chip if fitted.

5.3.11.8 TOFM Scope

This option allows the user to test the function of the UFM time of flight module using a calibrated test block.

5.3.11.9 TOFM Values

This option allows the user to test the function of the UFM time of flight module using a calibrated test block.

5.3.11.10 Heat

Using a schedule of inlet and outlet temperatures and fluid pressure, defined in EN1434-1 section 8, the meter runs calculations through its DSP and displays % error between calculated value and expected value.

5.3.12 System Info Menu

This menu allows the user to view key meter values.

5.3.12.1 Model Code

Show model code of the meter.

5.3.12.2 Serial No.

Show the unique serial number assigned to the meter during manufacture.

5.3.12.3 HW Issue

Show the HW version for the meter and associated TOFM.

5.3.12.4 SW Issue

Show the SW version for the meter and associated TOFM.

5.4 Diagnostics Menu

This menu allows the user to see a display of error reports, optional plug-in IO modules fitted, datalogger memory remaining (as a percentage and as an estimated time in hours) and other diagnostics.

There are 3 screens of diagnostics in total, press ENT to move between them.

The meter checks that the TOFM that is installed is functioning.

Each item is given a simple Pass/Fail indication. Some items also result in display of an icon along the bottom of the LCD.

The UFM has a series of icons along the bottom of the LCD and in the top right corner. The meanings of these icons are from left to right as they appear;

- SND, Audio buzzer on/off.
- LCD, LCD backlight on/off.
- CLK, RTC or timing error.
- DAT, Serial data streaming via RS232 or USB port.
- LOG, Datalogger is active. Changes to LOG FULL when memory is full.
- ERR, Serious microprocessor internal error.
- WARNING TRIANGLE, an error code is active, check installation.

and in the top right corner;

- **!** MARK**,** Low signal strength, high noise and/or poor signal to noise ratio, measurements may be unreliable, check installation.

The LCD also shows date, bottom left and time bottom right when in measurement mode.

In addition to showing icons, depending on the flow regime the UFM displays;

- Zero, no flow
- Lam, laminar
- Trans, transition
- Turb, turbulent

in the top-left of the display when in measurement mode.

Laminar flow is generally regarded to exist for Reynolds Number less than 2300, transition is in the range 2300 to 4000 and turbulent flow typically has a Reynolds Number greater than 4000.

5.5 Input/Output

As soon as the UFM is switched on a self-diagnostic program will start.

As part of this diagnostic the UFM polls to determine which if any optional plug-in IO modules are fitted in its expansion slots

If the range of fitted modules is found to have changed since last power on a message will be displayed prompting user action.

A list of plug-in IO modules fitted can also be found in the Diagnostics Menu.

The Input/Output menu allows the user to assign and program the IO modules as fitted in the meter.

Select a module

A list of available IO module types and their positions in the UFM meter will be shown against slot numbers.

The first 2 slots will usually contain the ultrasonic measurement module, TOFM;

- Slot 1 EMPTY SLOT
- Slot 2 TOFM

Since the TOFM module plugs into slot 2 but also bridges slot 1 then slot 1 arbitrarily appears as empty.

Off/On/Test

This display allows the user to select from a list;

- Off **(Default)**
- On
- Test

By default all modules are turned Off. Select On to turn a module on.

If a module is turned Off then the user is returned to the Main Menu.

If the user selects Test then the module runs a test routine appropriate to its type. For example, a current output module will sequence through a range of current output values. The user can attach an appropriate test device/meter to confirm the module is functioning correctly.

After test the user is returned to the Main Menu. The module state On/Off is returned to its value before the test was run.

Once the user turns a module on it is necessary to follow a sequence that fully programmes the module. The UFM will take the user through a sequence that is appropriate for each type of module. The complete sequence must be followed.

NOTE. Changes are only implemented and saved when the end of the programming sequence is reached.

Relay Output

Select Digital OP Mode

- Alarm
  - Alarm Source
    - Low Signal
    - Fault
    - System
    - Velocity
    - Rate
    - Energy
  - On point
  - Off point
- Pulse
  - Pulse Source
    - Flow Net Tot
    - Flow Pos Tot
    - Flow Neg Tot
    - Energy Net Tot
  - Step
  - Duration
- Batch Control
- Phase Detection

Open Collector Output

Select Digital OP Mode

- Alarm
  - Alarm Source
    - Low Signal
    - Fault
    - System
    - Velocity
    - Rate
    - Energy
  - On point
  - Off point
- Pulse
  - Pulse Source

Flow Net Tot
Flow Pos Tot
Flow Neg Tot
Energy Net Tot

Step

Duration

Batch Control

Phase Detection

Current Output 4-20mA

Iout Source
Velocity
Lower Value

Upper Value

Damping

Error
Hold
3.8mA/Off
21.0mA/On

Hold

Rate
Lower Value

Upper Value

Damping

Error
Hold
3.8mA/Off
21.0mA/On

Hold

Energy
Lower Value

Upper Value

Damping

Error

Hold
3.8mA/Off
21.0mA/On

Hold

TOFM

The TOFM module has no user programmable values.

Current Input

Iin Source
- Inlet
  - Iin Units
    - degC
    - degF
    - K
- Outlet
  - Iin Units
    - degC
    - degF
    - K
- Comp.
  - Iin Units
    - degC
    - degF
    - K
- Inlet+Comp.
  - Iin Units
    - degC
    - degF
    - K
- Outlet+Comp.
  - Iin Units
    - degC
    - degF
    - K

AI Batch

Span
- 0..20mA
- 4..20mA

Lower Value

Upper Value

PT100 Input

PT100 Source

Inlet
Outlet
Comp.
Inlet+Comp.
Outlet+Comp.

PT100 Dynamic
Dynamic
Offset
Fixed
Value

Modbus RTU

Address

Baud
9600
19200

Parity
None
Even
Odd

Stop Bits
1
2

Digital Input

Select Digital Input Mode
DI1 Batch
DI2 Batch

5.6 RS232/USB

This menu allows the user to change serial communication settings for the RS232 and USB ports.

5.6.1 Port

The user can select which of the 2 available serial ports are used for communication from a list;

- Off **(Default)**
- USB
- RS232

5.6.2 Mode

The user is prompted to select the mode for the RS232/USB from a list;

- Off **(Default)**
- LPT
- Diagnostics
- Data Dump
- Corr Dump

Selecting mode None turns the RS232/USB transmit off. The RS232/USB port can still receive.

Line Printer (LPT) streams measurement values out on the RS232/USB;

- Flow velocity
- Flow rate
- Flow positive totaliser
- Flow negative totaliser
- Flow net totaliser
- Energy
- Energy rate
- Energy positive totaliser
- Energy negative totaliser
- Energy net totaliser
- Pipe internal cross-sectional area
- Fluid density
- Fluid Specific Heat Capacity
- Inlet temperature
- Outlet temperature
- Fluid speed of sound

Diagnostics streams key diagnostic values on the RS232/USB;

- Flow velocity
- Flow rate
- Energy
- Energy rate
- Delta time

- Upstream transit time
- Signal amplitude
- Signal noise
- Signal gain
- Signal SNR
- Dropped comms counter
- Signal quality 1
- Signal quality 2
- Signal quality 3
- Control unit temperature
- Inlet temperature
- Outlet temperature
- Fluid temperature
- Error code 1
- Error code 2

Data and Corr dumps are intended for expert users. Data Dump outputs the received ultrasonic signal data, and Corr Dump outputs the calculated cross correlation data. This comma separated ASCII data can be useful or advanced diagnostics. When streaming the UFM will show a Timing error, this is normal.

5.6.3 Baud

The user is prompted to select the communication baud rate from a list;

- 9600 **(Default)**
- 19200
- 57600
- 115200

5.6.4 Parity

The user is prompted to select the communication parity from a list;

- None
- Even **(Default)**
- Odd

5.7 Datalogger

This menu allows the user to edit parameters specific to the meters internal datalogger.

The meter has a 16MB internal flash datalogger memory.

As soon as the UFM is switched on a self-diagnostic program will start.

As part of this diagnostic the UFM checks the function of the flash data memory hardware (4 individual chips, successful test indicated by a Pass for each) and reads any logged data to check its integrity (Progress shown by incrementing address). If no logged data is found then no progress will show.

A percentage figure of free logger memory remaining in terms of space and hours can also be found in the Diagnostics Menu.

5.7.1 Interval

The user is prompted to enter a datalogger interval.

Entering a value for Interval starts datalogging. An Interval of zero turns the data logger off.

When the interval is met then all meter measurement values are written to the datalogger memory.

Allowed values are ranged 0 to 255 s, default 0 s meaning off.

5.7.2 Erase

The user is prompted to erase the datalogger memory by selecting On/Off. By default memory is not erased

5.7.3 Energy Record

The user is prompted to turn logging of energy rate and totalisers On/Off. By default energy rate and totalisers are not logged.

5.7.4 Download

The user is prompted to download the datalogger memory over USB/RS232 by selecting On/Off. By default memory is not downloaded.

5.8 Batching Function

This menu allows the user to change settings relating to batch processing.

5.8.1 Flow Batch Trigger

The user can select how the batch process is triggered from a list;

- Key Input (Default)
- AI Up Edge
- AI Down Edge
- DI1 Up Edge
- DI1 Down Edge
- DI2 Up Edge
- DI2 Down Edge

If Analogue Input (AI) is selected then the totaliser starts on a signal from a current input module, see Input/Output section.

Depending on whether the trigger is Up or Down the totaliser starts as the input current passes through 12 mA going up to 20 mA or down to 0 mA respectively.

If Digital Input (DI1 or 2) is selected then the totaliser starts on a signal from a digital input module, see Input/Output section.

Depending on whether the trigger is Up or Down the totaliser starts as the input goes high or low.

5.8.2 Flow Batch Target

The user is prompted to enter a target value for the batch controller. The value is in the user selected totaliser units, see above.

When the batch totaliser reaches this target then a relay or open collector output can be activated, see Input/Output section.

Allowed values are ranged 1.0 to 100000.0, default 1.0.

5.8.3 Flow Batch Controller

The user starts the batch process by selecting this menu function and following the instructions on the LCD.

The display will show flow rate and batch total and prompt for a key press, current input or digital depending on Flow Batch Trigger.

If key input is required press ENT to start otherwise apply a current or digital input.

Once the batch is started it is possible to press ESC to exit the batch process early.

The displayed batch total will accumulate to the target value and when this is reached the end of batch operation will occur, relay or open collector switching if selected.

Otherwise press ENT to exit to the Main Menu.

5.9 Manual Totaliser Function

This menu allows the user to manually start and stop a dedicated totaliser. Follow the instructions on the LCD.

Simply press ENT to start and ESC to stop.

5.10 Phase Detection Function

This menu allows the user to change settings relating to phase detection. The meter can identify different phases or fluids flowing in pipes by making speed of sound measurements in the fluid(s).

The user starts the Phase Detection process by selecting this menu function and entering a value for the Phase Detection Target.

5.10.1 Phase Detection Target

The user is prompted to enter a target value for the longitudinal speed of sound of the fluid in the pipe.

Allowed values are ranged 100.0 to 3500.0, default 1498 m/s (water at 20 degC).

Press ENT to start, once the process is started it is possible to press ESC to exit the process.

The meter will display the measured speed of sound in the flow, if the Phase Detection Target value is crossed relay or open collector switching will occur if selected.

Otherwise press ENT to exit to the Main Menu.

5.11 Heat Metering

Heat meters measure the energy necessary to provide hot water or cooling to a location such as a building or room.

The meter measures the energy on the supply or return side of a heating (boiler) or cooling (chiller) device by measuring the flow rate of heat or cooling fluid and the temperature difference between the supply and return legs of the system.

The pipe from the source of heat or cooling entering a location is known as the Flow or inlet pipe.

The pipe from the location returning to the source is known as the Return or outlet pipe.

The meter is programmed to be installed on the return pipe. This is the colder pipe for heating systems and the warmer pipe for cooling systems.

With the addition of PT100 plug-in modules for real-time measurement of inlet and outlet temperature the UFM can function as a heat meter.

For a boiler heating installation the flow measurement needs to be made on the cold side of the system.

For a chiller cooling installation the flow measurement needs to be made on the warm side of the system.

If the correct meter installation position is not used and/or the temperature sensing elements are not placed on the correct flow/return legs then a meter may be up to 10 % inaccurate.

5.11.1 Calculation Method

This list allows the user to select how heat measurements are made;

- SHC **(Default)**
- EN1434-1
- GSSSD

The default calculation uses Specific Heat Capacity, mass flow and temperature difference between inlet and outlet to make the heat calculations.

EN1434-1 uses calculations defined in the standard section 8. Uses specific volume and enthalpy to make the heat calculations.

GSSSD makes calculations as defined by the Russian standard. Uses enthalpy, density and pressure to make the heat calculations.

5.11.2 Pressure

This value, in MPa is only used as part of the GSSSD method.

Allowed values are ranged 0.05 to 30.0 MPa, default 0.1 MPa.

5.11.3 Specific Heat Capacity

The UFM can make energy calculations using the Specific Heat Capacity (SHC) method, where the user must manually enter values for pipe inlet and outlet temperature.

The user can enter a value for the Specific Heat capacity of the fluid flowing in the pipe. Allowed values are ranged 0.0 to 10.0 J/(g.K), default 4.1856 J/(g.K) (Water at 18 degC).

Appendix A Transducer parameters

These parameters are only intended for trained service personnel. They are normally read from an external transducer memory chip which is supplied with a matched pair of transducers.

Wedge Angle

The user is prompted to enter a value for the transducer wedge angle.

Allowed values are ranged 0.0 to 90.0 deg, default 40.0 deg.

Wedge SOS 20

The user is prompted to enter a value for the speed of sound in the wedge at 20 degC.

Allowed values are ranged 500.0 to 7000.0 m/s, default 2522.0 m/s.

Wedge SOS 60

The user is prompted to enter a value for the speed of sound in the wedge at 60 degC.

Allowed values are ranged 500.0 to 7000.0 m/s, default 2522.0 m/s.

Crystal Offset

The user is prompted to enter a value for the offset position of the piezo crystal on the wedge.

Allowed values are ranged 0.0 to 100.0 mm, default 11.6 mm.

Spacing Offset

The user is prompted to enter a value for the transducer offset position.

Allowed values are ranged 0.0 to 100.0 mm, default 30.0 mm.

Code

The user is prompted to select the transducer frequency in kHz from a list;

- 500
- 952
- 1000 **(Default)**
- 1052
- 1100
- 1818
- 2000
- 2222
- 4000
- 4500

The default value is 1000 kHz, DM10 sensor.

Zero Flow Offset

The user can view/edit inherent offsets in the transducers.

Allowed values are ranged -20.0 to +20.0 ns, default 0.0 ns.

Zero Calibration and Zero Tracking adjust this value in real time when measuring when they are enabled.

K factor

Allows the entry of a factory calibrated meter factor.

Appendix B Error codes

Error codes 1 and 2 are a pair of 16 bit values, where each bit represents an error flag with value 0 when there is no error and 1 when an error condition is present.

Error code #1

- 0 Processor internal math error
- 1 Processor internal stack error
- 2 Processor internal address error
- 3 Processor internal oscillator error
- 4 Processor internal SPI1 bus error
- 5 Processor internal SPI2 bus error
- 6 Meter RTC IC error
- 7 Processor internal I2C2 bus error
- 8 Meter external FRAM memory error
- 9 Meter external datalogger Flash memory error
- 10 Meter control unit temperature IC error
- 11 Meter TOFM communications error
- 12 Measurement timing error
- 13 Meter IO bus error
- 14 Measurement signal amplitude error
- 15 Measurement signal SNR error

Error code #2

- 0 Measurement dropped comm. error
- 1 Advanced diagnostic 1
- 2 Advanced diagnostic 2
- 3 Advanced diagnostic 3
- 4 Advanced diagnostic 4
- 5 Spare
- 6 Spare
- 7 Spare
- 8 Spare
- 9 Spare
- 10 Spare
- 11 Spare
- 12 Spare
- 13 Spare
- 14 Spare
- 15 Spare

Spare bits are always 0.