Spire Metering Technology

EF12 Series

Solar-Powered Ultrasonic Flowmeter

User's Manual

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The following conventions are used through this manual:

WARNING!

Read the declaration carefully before starting any other action!

CAUTION!

Attention! Damage could occur to the device if handled inappropriately.

For questions, please call us at +1 978 263 7100 or email us at support@spiremt.com.

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1. Introduction

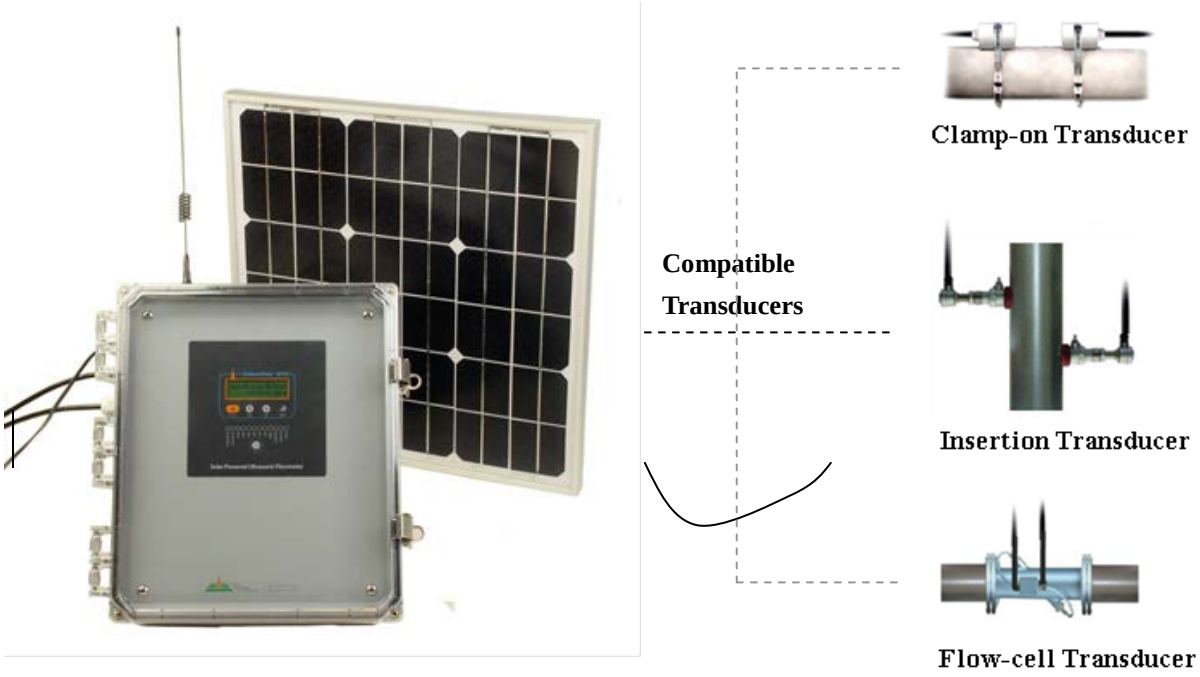
§1.1 Preface

EF12x series solar-powered ultrasonic flowmeters are a family of flowmeters based on our latest innovation. With its GPRS/GSM wireless capability (optional), EF12 is an ideal choice for applications in rural area where electrical power is not accessible and automatic meter reading is required.

Depending on the transducer used, there are three varieties in this family,

- EF12B: consisted of a EF12 main unit and a pair of clamp-on transducers
- EF12C: consisted of a EF12 main unit and a pair of insertion transducers
- EF12G: consisted of a EF12 main unit and a flow-cell transducer

Clamp-on version (EF12B) is non-intrusive and easy to install. Insertion version (EF12C) has excellent long-term stability and better accuracy. Flow-cell version (EF12G) has the best accuracy amount the three. It is also pre-programmed in factory, thus, it is actually a play & play device.



EF12 flowmeter is a compact, high performance, solar powered ultrasonic flow measurement device. It not only inherits all the nice features of our legacy Stuf-300xx products, but also

integrates the latest technology advancements in surface-mount electronics, ultrasonic transducer design, high accuracy transit-time flow measurement and digital signal processing.

Based on transit-time principle, the EF12 is able to measure liquid flow in a closed pipe reliably and accurately. The liquid should be full in the pipe, and should contain no or small amount of particles or air bubbles. Examples of applicable liquids are: water (hot water, chilled water, city water, sea water, etc.), sewage, oil (crude oil, lubricating oil, diesel oil, fuel oil, etc.), chemicals (alcohol, acids, etc.), waste water, beverage, liquid food, solvents and other liquids.

EF12 provides versatile output interfaces, both analog and digital, which can be easily used by a host computer. External USB data logger can be also connected to the 4-20mA output to log flowrate data. The RS485 communication interface together with MODBUS support makes EF12 the idea device for flowmeter networking.

To get you up and running the flowmeter quickly, please refer to document EF12 Quick Start.pdf.

§1.2 Features

- Low-power consumption for both GSM/GPRS modem and ultrasonic flowmeter
- Solar powered. No other power supply is needed. Solar panel rated at 20Watts
- Built-in rechargeable battery (17AH) and charging circuit able to maintain 7 days of operation without sunshine
- Robust, NEMA/UL-50 Type 4X weather-proof enclosure
- High accuracy. Normally ±1%. Could be 0.5% when in-situ calibration is available
- No moving parts to worn out, thus, long life-span.
- Maintenance-free, thus, low operation cost
- No pressure drop, no flow disturbance. Big savings on high pressure pipes
- Excellent long-term stability. System accuracy does not degrade over time
- Bi-directional
- Wide flow range. Large turn-down ratio
- Suitable for all commonly used pipe materials
- Suitable for most pure liquids and liquids with minor particles
- Robust performance due to proprietary signal quality tracking and self-adaptation technology
- Built-in flow totalizers
- Internal data logger: last 512 daily net flow values and last 128 monthly net

flow values

- External data logger (optional): 32,000 data capacity. USB interface
- Optional StufManager™ PC software for data collection
- LCD with backlight. 2 x 20 letters. 4 tactile-feedback membrane keypad.
- RS-485 interface with MODBUS support. Well suited for reliable networking

Environment: For main unit: -10˚C ~ 70˚C. For transducers: -20˚C ~ 80˚C or –20˚C ~ 150˚C depending on transducer selected

§1.3 Flow Measurement Principle

The EF12 ultrasonic flowmeter is designed to measure the velocity of liquid within a closed conduit. It uses the well-known transit-time measurement principle plus our proprietary signal processing and ultrasonic transceiving technologies.

As shown in Figure 1.1, the EF12 utilizes a pair of ultrasonic transducers which are mounted on the pipe upstream and downstream respectively. Each transducer functions as both ultrasonic transmitter and receiver. The EF12 flowmeteroperates by alternately transmitting and receiving a coded burst of sound energy between the two transducers. The transit-times in both upstream and downstream directions are measured. The difference of the two transit times is directly and exactly related to the velocity of the liquid in the pipe,

$$V = \frac{MD}{\sin 2\theta} \times \frac{\Delta T}{T_{up} \bullet T_{down}}$$

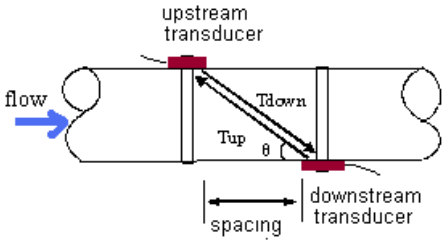


Figure 1.1: Transit-time flow measurement principle

Where:

θ is the angle between the sound path and the flow direction

M is the number of times the sound traverses the flow

D is the pipe diameter

T_{up} is the time for the beam traveling from upstream the transducer to the downstream transducer

T_{down} is the time for the beam traveling from the downstream transducer to the upstream transducer

$\Delta T = T_{up} - T_{down}$

The flow rate is then computed by combining the velocity information with pipe parameters and a scale factor. The scale factor is normally determined by calibration in factory.

Three types of transducers can be used with the EF12 flowmeter: clamp-on transducer, insertion transducer and flow-cell transducer. All of them do not block the flow, thus, do not generate pressure drop. None of them has moving parts, thus, they are virtually maintenance-free. The transducers can be mounted in V-method where the sound transverses the pipe fluid twice, or in W-method where the sound transverses the pipe fluid four times, or in Z-method where the transducers are mounted on opposite sides of the pipe and the sound crosses the pipe fluid once. The selection of the mounting methods depends on pipe and liquid characteristics. Please refer to the related Appendixes for more details.

§1.4 Packaging List (Standard)

1. EF12 flowmeter	1 unit
2. Transducers	
(1) For clamp-on installation:	
M1-type clamp-on transducer for 2”~28” pipe	1 pair
Clamp-on fixture	1 set
Acoustic couplant	1 unit
(2) For insertion installation:	
Insertion transducer for pipes of 3” and larger	1 pair
Hot-taping tool for metal pipe	1 set
(3) For inline flow-cell installation:	
Flow-cell transducer	1 set
3. Transducer cable, 15ft	1 pair
4. User’s Manual	1 unit

§1.5 Optional Parts

Clamp-on transducers:

S1-type clamp-on transducer for small pipe (1”~4”, -20°C~90°C)

S1HT-type high-temperature clamp-on transducer for small pipe (1”~4”, -20°C~150°C)

M1-type clamp-on transducer for medium size pipe (2”~28”, -20°C~90°C)

M1HT-type high-temperature clamp-on transducer for medium size pipe (2”~28”, -20°C~150°C)

L1-type clamp-on transducer for large pipe (11”~240”, -20°C~90°C)

Corrosive-resistant transducer: S1P, M1P or L1P

Clamp-fixtures

Insertion transducers:

Insertion transducer for pipe size of 3” or larger

Hot-tapping tool for insertion transducer installation

Mounting saddle for non-metal pipes

Flow-cell transducers:

π-type flow-cell transducer for small pipe (3/8”~2”)

Standard flow-cell transducer for large pipe (2”~40”)

Dedicated shielded transducer cable

Data logger module

GPRS/GSM module

RS485-USB converter

StufManager PC software

§1.6 Typical Applications

The EF12 flowmeter can be applied to a wide range of pipe flow measurements. Applicable liquids include pure liquids as well as liquid with small quantity of tiny particles. Examples are:

Water (hot water, chilled water, city water, sea water, waste water, etc.);
Sewage with small particle content;
Oil (crude oil, lubricating oil, diesel oil, fuel oil, etc.);
Chemicals (glycol, alcohol, acids, etc.);
Plant effluent;
Beverage, liquid food;
Ultra-pure liquids;
Solvents and other liquids.

Applications sorted by industry / process are:

Water and waste water management;
Water and waste water treatment plants;
Power plants, such as nuclear power plants and hydraulic power plants;
Mining and metallurgy plants;
Petroleum process monitoring and control;
Chemical process monitoring and control;
Pulp and paper process monitoring and control;
Food and beverage processing;
Marine maintenance and operation;
Pipeline leakage detection;
Energy supply and production systems, such as geothermal system, HVAC, BMS, etc.
Flow measurement networking.

§1.7 Product Identification

Each set of the EF12 series flowmeter has a unique product identification number or ESN (electronic serial number) written into the software that can only be modified with a special tool by the manufacturer. In case of any hardware failure, please provide this number which is located on menu window M61 when contacting the manufacturer.

§1.8 Specifications

Main Unit	Linearity	Better than ±1%.
	Accuracy	±1% of velocity reading, plus ± 6mm/s. Could be better when in-situ calibration is conducted. Amoung the three types of transducers, flow-cell is most accurate, followed by insertion type, then the clamp-on type.
	Repeatability	±0.2%.
	Velocity	-52 ~ 52 ft/s (-16 ~ 16 m/s), bi-directional
	Measurement Period	0.5s. Can be set to 0 ~ 99s.
	Display	2x20 char LCD with backlight.
	Keypad	4 keys
	Units	English (U.S.) or metric.
	Output	Analog output: Isolated 4-20mA or 0-20mA current output. Impedance 0~1kΩ. Accuracy 0.1%.
		Internal Alarm (Buzzer): user programmable.
		Isolated RS485: 2-wire half-duplex with surge protection, supports MODBUS protocol and proprietary flowmeter protocol.
		GPRS / GSM module (optional): for remote monitoring and remote control.
	Others	Self-diagnosis. RTC (real-time clock) for calendar. Data logger (optional). Capable of offline compensation for flow totalizer, automatic / manual selectable. Automatically record the following information: · The totalizer data of the last 64 days / 64 months / 5 years; · The power-on time and corresponding flow rate of the last 64 power on and off events. Allow manual or automatic flow loss compensation · The instrument working status of the last 64 days

	Enclosure	Robust, NEMA/UL-50 Type 4X weather-proof enclosure Size: 14”x12.5”x5.5” (356mm*318mm*140mm)
Transducer	Clamp-on	S1-type: for pipe size 1”~4” (DN25~DN100mm) S1HT-type: for pipe size 1”~4” (DN25~DN100mm), high temperature (to 150˚C) M1-type: for pipe size 2”~28”(DN50~DN700mm) M1HT-type: for pipe size 2”~28”(DN50~DN700mm) , high temperature (to 150˚C) L1-type: for pipe size 11”~240”(DN300~DN6,000mm) S1P / M1P / L1P types: the corrosive-resistant version of S1 / M1 / L1
	Wetted - Insertion	Used for pipe size of 3” (DN80mm) or larger. Optional hot-tapping installation tool available. Optional saddle for non-metal pipe available.
	Wetted - Flow-cell	π-type flow cell transducer: for pipe size 3/8”~ 2” (DN10~DN50mm). Standard flow cell transducer: for pipe size 2”~40” (DN50~DN1,000mm).
Liquids	Liquid Types	Virtually all commonly used clean liquids. Liquids with small quantity of tiny particles may also be applicable. Particle size should be less than 100um, particle concentration less than 20,000ppm (2%). Liquids should contain no or very minor air bubbles. Examples are chilled/hot water, sea water, waste water, chemical liquids, oil, crude oil, alcohol, beer, etc.
	Liquid Temp	32˚F ~ 212˚F (0˚C ~ 100˚C) for standard clamp-on transducers 32˚F ~ 302˚F (0˚C ~ 150˚C) for high-temperature clamp-on transducers, as well as wetted transducers (insertion type and flow-cell type).
	Suspension concentration	< 20,000ppm and particle size less than 100um. May contain very small amount of air bubbles.
Pipe	Pipe Size	3/8” ~ 240” (DN10mm ~ DN6,000mm), depending on transducer type.
	Pipe Material	All metals, most plastics, fiber glass, etc. Allow pipe liner.
	Pipe Straight run	15D in most cases, 30D if a pump is near upstream, where D is pipe diameter.
Cable	Shielded transducer cable. Standard length 15’ (5m). Can be extended to 1640’ (500m). Contact the manufacturer for longer cable requirement. Cable should not be laid in parallel with high-voltage power line, neither should it be close to strong interference source such as power transformers.	
Environment	Temperature	Main unit: 14˚F ~ 131˚F (-10˚C ~ 55˚C).
		Clamp-on transducer: -4˚F ~ 194˚F (-20˚C ~ 90˚C) for standard type (S1/M1/L1), -4˚F ~ 302˚F (-20˚C ~ 150˚C) for high-temperature type (S1HT/M1HT). Insertion and flow-cell transducer: -4˚F ~ 302˚F (-20˚C ~ 150˚C).
	Humidity	Main unit: 85% RH
		Transducer: water-immersible, water depth less than 10’ (3m)

Power	DC: 9 ~ 24VDC, Power consumption: < 1W at 9VDC. If you need lower power consumption, please contact the manufacturer
Weight	Main unit: 21 lbs

2. Installation and Measurement

§2.1 Unpacking

Please unpack the shipping box and check the parts and documents against the packing slip. If there is something missing, the device is damaged, or something is abnormal, please contact us immediately and do not proceed with the installation.

WARNING!

The EF12x can be used to measure the flow of many kinds of liquids. Some of the liquids may be hazardous. It is very important that you comply with local safety codes and regulations in installing and using electronic devices in your area.

§2.2 Installation Considerations

This section provides guidelines for installing the EF12 main unit (the flowmeter) and its transducers.

§2.2.1 Mounting the Main Unit

The EF12 main unit electronics are housed in an NEMA/UL-50 Type 4X weather-proof and dust-tight enclosure. Therefore, the main unit can be installed indoor and outdoor. Usually, it is mounted in a meter shed or on a location where one can easily access for meter testing and servicing. Please refer to Appendix §9.1 for the enclosure information.

Note: because the unit is not water-proof, be sure it is not exposed to rain or water when it is installed outdoor.

§2.2.2 Installing Transducers

First, you need to select a proper installation site. For this, one usually needs to consider the accessibility of the location, operating space needed for the installation, safety code compliance, etc. In addition, flow and pipe conditions near the installation site are also very important. Please refer to section §2.8 for site selection details.

Then, follow the installation guidelines given in Appendix §9.2 for installing clamp-on transducers.

If you ordered wetted transducer, either insertion type or flow cell type, please refer to Appendix §9.3 and §9.4 for installation instructions.

Distance from Main Unit to Transducers

In general, the closer the transducers to the main unit, the better the signals.

Transducer Cables

EF12 utilizes a double-balanced driving technique for high performance ultrasonic transimision and receiving. It requires twisted shielded cables for the transducers. We recommend to use the cable supplied by the manufacturer. If you want to do the transducer cabling yourself, please consult the manufacturer in advance.

Try not to route the transducer cable along with high current AC lines. Aviod strong interference sources. Make sure the cables and cable connections are protected from weather and corrosive conditions.

WARNING!

The transducers may have static charges accumulated during transportation. Before connecting the transducers to the main unit, please do discharge the transducers in a safe area by shorting the center conductor of the transducer cable connectors to the metal shield of the connector.

§2.2.3 Power Supply Wiring

Please refer to Appendix §9.1 for wiring information.

Backup Battery

There is a 3V coin cell battery, CR2032, on the main board which is used to backup the calendar real-time clock (RTC). When the main power is off, this battery will keep RTC running. Its lifetime is normally about 3 years. Replace the battery with the same type when necessary. Please disconnect the main power and wear an anti-static wrist strap to prevent electro-static damage to the main board electronics.

If time stamping is not needed for data recording, you may remove this battery from the board.

WARNING!

There might be risk of explosion if the battery is replaced with an incorrect type. Batteries should be recycled where possible. Disposal of used batteries must comply with local environmental regulations.

§2.2.4 Other Electrical Connections

Wiring RS485

Refer to sections §6.2 and Appendix §9.1 for details.

Wiring 0/4-20mA Output

Using standard twisted-pair wiring. Refer to section §3.16 for details.

§2.3 Power Up

The EF12 does not have power ON/OFF switch. When it is connected to power, it will start to run automatically.

After the power is turned on, the flowmeter will run a self-diagnostic program, checking first the hardware and then the software integrity. If there is any abnormality, corresponding error messages will be displayed. (Please refer to chapter 5 for error code explanations.)

WARNING!

Before connecting the device to power source, please do a final check to make sure all the wirings are correct and all the local safety codes are followed.

After successful internal checks, the EF12 will display menu window #01 (short for M01), or the menu window which was active at last power off. It will also start the measurements by using the parameters configured and saved last time by the user or by the initial program.

The flow measurement program always operates in the background of the user interface. This means that the flow measurement will keep running regardless of any user menu window browsing or viewing. Only when the user enters new pipe parameters will the flowmeter change measurement to reflect the new parameter changes.

When the power is turned on or new pipe parameters are entered, the flowmeter will enter into a self-adjusting mode to adjust the gain of the receiving circuits so that the signal strength will be within a proper range. By this step, the flowmeter finds the best system gain which matches the pipe material and fluid type. The user will see the progress by the number s1, s2, s3 and s4, located on the upper left corner of the LCD display. If the self-adapting process is completed successfully, letter “#R” will be displayed.

When the user adjusts the position of the installed transducers, the flowmeter will re-adjust the signal gain automatically.

Any user-entered configuration value can be stored in the NVRAM (non-volatile memory) by using M26, until it is modified by the user.

§2.4 Display and Keypad

§2.4.1 Local Display and Keypad

EF12 has a 2 row x 20 char LCD display and a 4-key keypad. The 4 keys, MENU key, ▲ key, ▼ key and ENT key, provide an economical user interface to browse all the menu windows in the flowmeter. They also allow the user to program the flowmeter without using a computer.

MENU key is for direct menu jump over. Whenever the user wants to proceed to a certain menu window, the user can press this key followed by a 2-digit number.

MENU key is shortened as the 'M' key hereafter when referring to menu windows.

▲ key is used to go to the previous menu, or, to increase the digit number.

▼ key is used to go to the next menu, or, to move the cursor to the next position.

ENT key is the ENTER key for any input or selections.

Figure 2.1(a) Front Panel, LCD/keypad

Example 1: jump to menu window 91 (M91).

Press MENU key. Then, press ▲ key multiple times until 9 shows up. Press ▼ once, ▲ once again, and finally, ENT key to confirm.

Example 2: if the current window is M10, press ▼ key once will go to M11.

If current window is M11, press ▲ key once will go to M10.

Example 3: enter pipe OD = 1.315".

(1) If the unit system is not English, you may go to M30 to change the unit to English system.

(2) If current window is not M11, you need to jump to M11.

(3) Enter 1.315 now:

Press ENT key once to start.
Press ▲ key once to get digit 1. Then, press ▼ key once to move to next position.
Press ▲ key multiple times until . comes up. Then, press ▼ key once to move to next position.

Press [▲] key multiple times until digit 3 comes up. Then, press [▼] key once to move to next position.
Press [▲] key one time until digit 1 comes up. Then, press [▼] key once to move to next position.
Press [▲] key multiple times until digit 5 comes up.
Press [ENT] key once to confirm the change.

§2.4.2 Auxiliary Display/Keypad Interface

An auxiliary but more sophisticated user interface is the StufManager™ software. As illustrated in Figure 2.1(b), the interface has 16 keys and a two line display window.

Keys [0] ~ [9] and [.] are keys to enter numbers.

Key [↑/+] (or [UP/+]) is the going UP key when the user wants to go to the upper menu window. It also works as + key when entering numbers.

Key [↓/-] (or [DN/-]) is the going DOWN key when the user wants to go to the lower menu window. It also works as the – key when entering numbers.

Key [←] is the backspace key when the user wants to go left or wants to backspace the left character that is located to the left of the cursor.

Key [ENT] is the ENTER key for any input or selections.

Figure 2.1(b) Software display/keypad

Key [MENU] is the key for the direct menu window jump over. Whenever the user wants to proceed to a certain menu window, the user can press this key followed by a 2-digit number.

The [MENU] key is shortened as the ‘M’ key hereafter when referring to menu windows.

§2.5 Menu Windows

The EF12 organizes the parameters, status and results in menu format. Each menu has a menu number, a menu name and a value. There are about 100 menus. You may use the auxiliary user interface (Fig. 2.1(b)) to view those menus easily. You may also be able to access those menus though RS485 by sending keypad emulation command.

In the following, we assume the auxiliary user interface will be used for the convenience of explanation. For emulation command, please refer to section 6.4 for details.

The menu windows are numbered by M00, M01, M02, …, M99, M+0, M+1, etc. There are two methods to visit a menu window:

(1) Direct jump in. Simply press the MENU key followed by a 2-digit number. For example, if you want to visit menu window M11 for pipe outer diameter, press the following three keys consecutively, MENU 1 1.

(2) Press the ↑/+ or ↓/- key. Each time of the ↑/+ key pressing will lead to the lower-numbered menu window. For example, if the current window is on M12, the display will go to window M11 after the ↑/+ key is pressed once.

You do not need to remember all the menu windows. Just remember the most commonly used window numbers and the approximate window number of some uncommonly used windows would be sufficient. You can always use ↑/+ or ↓/- key to find the right window.

There are three different types of menu windows:

(1) Menu windows for number entering, e.g., M11 for setting up pipe outer diameter.

(2) Menu windows for option selection, e.g., M14 for the selection of pipe materials.

(3) Results display windows, e.g., window M00 for displaying flow rate, etc.

For number entering windows, the user can directly press the digit keys if the user wants to modify the value. For example, if the current window is on M11, and the user wants to enter 219.2345 as the pipe outer diameter, then, the flowing keys should be pressed: 2 1 9 . 2 3 4 5 ENT.

For option selection windows, the user should first press the ENT key to get into option selection mode. Then, use ↑/+, ↓/- , or digit key to select the right option. Consequently, press the ENT to make the selection.

For example, assume your pipe material is stainless steel and you are currently on menu window M14 which is for the selection of pipe materials (if you are on a different window, you need to press MENU 1 4 first in order to enter into the M14 window.) You need to press the ENT key to get into the option selection mode. Then, either press the ↑/+ or ↓/- key to make the cursor on the line that displays “1. Stainless Steel”, or press the 1 key directly. At the end, press ENT again to make the selection.

Generally, the ENT key must be pressed to get into the option selection mode for option

modifications. If the “Locked M47 Open’ message is indicated on the bottom line of the LCD display, it means that the modification operation is locked out. In such cases, the user should go to M48 to have the instrument unlocked before any further modification can be made.

§2.6 Menu Window List

M00~M09 windows for the display of the instantaneous flow rate, net totalizer value, positive totalizer value, negative totalizer value, instantaneous flow velocity, date time, current analog input values, current working status, etc.

M10~M29 windows for entering system parameters, such as pipe outer diameter, pipe wall thickness, liquid type, transducer type, transducer installation method, etc. Transducer installation spacing is then calculated according to those parameters and displayed on one of the windows. .

M30~M38 windows for flow rate unit selection and totalizer configuration. User can use these windows to select flow rate unit, such as cubic meter or liter, as well as to turn on / off each totalizer, or to reset the totalizers.

M40~M49 windows for setting response time, zeroing / calibrating the system, locking / unlocking keypad, changing network address ID, password, etc.

M50~M89 windows for digital and analog outputs, such as scheduled output, RS485 output, relay output, analog current loop output, LCD, frequency output, alarm output, analog inputs. Besides, there are also windows for configuring analog inputs, date / time, and day/month/year accumulator.

M90~M94 windows for displaying diagnostic data, including the installation triplet. Those data are very useful when doing a more accurate measurement.

M95 Upon entering into this window, the circular display function is started automatically. The following windows will be displayed one by one, each window will stay for about 4 seconds: M95 ->M00 -> M01 -> M02 -> M03 -> M04 -> M05 -> M06 -> M07 -> M08 -> M09 -> M90 -> M95.

M+0~M+9 windows for some additional functions, including a single precision calculator, display of the total working time, and display of the time and the flow rate when the device is turned on and turned off.

Other menu windows are used for factory debugging.

For detailed explanation of the above windows please refer to chapter 3 “How to” and chapter 4 “Menu Window Details”.

§2.7 Steps to Configure the Parameters

In order to make the EF12 work properly, one must program the flowmeter with application information and installation information properly, so that the flowmeter is able to lock to the right signal. The flowmeter will also automatically calculate the transducer spacing which is useful for you to install the transducers.

If you are using flow-cell transducer, however, most of the parameters may have already been programmed in the factory. You may only need to verify the fluid information (M20-M21), make sure the liquid type in M20 is what is in your pipe. Note that the pipe information (M11-M19) should be those of the flow-cell, not that of your pipe.

If you are using clamp-on or insertion type transducer, please follow these steps to configure the system:

(1) Pipe size and pipe wall thickness

For standard pipe, please refer to Appendix §9.4 for outer diameter and wall thickness data. For non-standard pipe, the user has to measure these two parameters.

Enter OD and wall thickness in M11 and M12. The flowmeter will calculate the ID and put it into M13.

(2) Pipe materials

For standard pipe material, select the proper type from the list in M14. The sound speed value of that material, which was pre-stored in the memory, will be used automatically.

For non-standard pipe material, the sound speed of the material must be entered. Please refer to Appendix §9.5 for sound speed data.

(3) Liner material, its sound speed and liner thickness

If liner exists, enter the liner parameters in M16-M18.

(4) Liquid type

For standard liquid material, select the proper type from the list in M20. The sound speed and viscosity values of that material, which were pre-stored in the memory, will be used automatically.

For non-standard liquid material, the sound speed and viscosity of the material must be entered. Please refer to Appendix §9.5 for sound speed and viscosity data.

(5) Transducer type

Transducer type selection is in M23.

For S1/M1/L1 type, select Standard S1/ Standard /M1/ Standard L1.

For insertion type, select Insertion B

For flow-cell transducer, select Pi-Transducer for Pi-type and Insertion B for standard type.

(6) Transducer mounting method

V-method and Z-method are the common methods. Make selection in M24.

Refer to Appendix §9.2 on which method to use.

(7) Transducer spacing
Write down the transducer spacing in M25. You will use it later when install the transducers.

(8) Save configuration
In M26, press ENT key, select item 1, and press ENT key again. Wait a few seconds for the flowmeter to reboot. This will store the parameters into the non-volatile Flash memory.

Example: For standard (commonly used) pipe materials and standard (commonly measured) liquids, the parameter configuration steps are as following:

(1) Press keys MENU 1 1 to enter into M11 window. Enter the pipe outer diameter through the keypad and press ENT key.

(2) Press key ↓/- to enter into M12 window. Input the pipe thickness through the keypad and press ENT key.

(3) Press key ↓/- to enter into M14 window. Press ENT key to get into the option selection mode. Use keys ↑/+ and ↓/- to scroll up and down to the proper pipe material, and then press ENT key.

(4) Press key ↓/- to enter into M16 window. Press ENT key to get into the option selection mode. Use keys ↑/+ and ↓/- to scroll up and down to the proper liner material, and then press ENT key. Select “No Liner”, if there is no liner.

(5) Press key ↓/- to enter into M20 window. Press ENT key to get into the option selection mode. Use keys ↑/+ and ↓/- to scroll up and down to the proper liquid, and then press ENT key.

(6) Press key ↓/- to enter into M23 window. Press ENT key to get into the option selection mode. Use keys ↑/+ and ↓/- to scroll up and down to the proper transducer type, and then press ENT key.

(7) Press key ↓/- to enter into M24 window. Press ENT key to get into the option selection mode. Use keys ↑/+ and ↓/- to scroll up and down to the proper transducer mounting method, and then press ENT key.

(8) Press key ↓/- to enter into M25 window. The transducer installation distance will be displayed on the window. Based on this distance and the transducer installation method selected above, install the transducers on the pipe (refer to Appendix §9.2 for more installation details.)

(9) After installation is completed, check if the triplet (signal strength S, signal quality Q and transit-time ratio R) are in the right range. Press keys MENU 9 0 to enter into M90 window to read the value for S and Q and press MENU 9 1 to read the value for R.

(10) Press MENU 2 6 to enter into window M26, press ENT 1 ENT to save the above configuration results into non-volatile memory.

(11) Press MENU 0 1 to enter into window M01 to read the measurement result.

§2.8 Transducer Mounting Allocation

The first step in the installation process is to select an optimal location for installing the transducers in order to make the measurement reliable and accurate. Prior to installation, having a basic knowledge about the piping and its plumbing system is recommended.

An optimal location would be defined as a long straight pipe line full of liquid that is to be measured. The piping can be in vertical or horizontal position. The following shows examples of optimal locations.

Principles to select an optimal location:

(1) Pipe must be full of liquids at the measurement site.

(2) No heavy corrosion of deposition inside of the pipe.

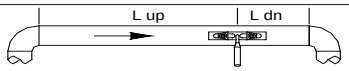
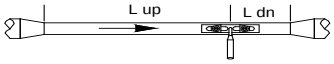
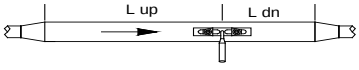
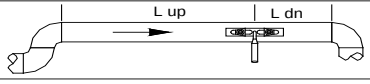
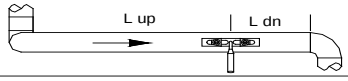
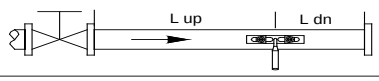
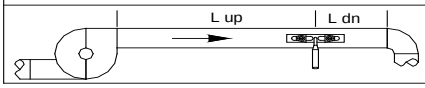
(3) Must be a safe location.

(4) The straight pipe should be long enough to eliminate irregular-flow-induced error. Typically, the length of the straight pipe should be 15 times of the pipe diameter, the longer the better. The transducers should be installed at a pipe section where the length of the straight pipe at upstream side is at least 10D and at downstream side is at least 5D, where D stands for pipe outer diameter.

(5) If there are flow disturbing parts such as pumps, valves, etc. on the upstream, the straight pipe length should be increased (refer to the table on the right for more details.) The disturbance strength are in the following order (low to high): *Single Bend -> Pipe Reduction / Enlargement -> Outflow Tee -> Same Plane Multiple Bends -> Inflow Tee -> Out of Plane Multiple Bends -> Valve -> Pump.*

(6) Make sure that the temperature on the location does not exceed the range for the transducers. Generally speaking, the closer to the room temperature, the better.

(7) Select a relatively new straight pipe line if it is possible. Old pipe tends to have corrosions and depositions, which could affect the results. If you have

Piping Configuration and Transducer Position	Upstream Dimension L up x Diameters	Downstream Dimension L dn x Diameters
	10D	5D
	10D	5D
	10D	5D
	12D	5D
	20D	5D
	20D	5D
	30D	5D

to work on an old pipe, we recommend you to treat the corrosions and depositions as if they are part of the pipe wall or as part of the liner. For example, you can add an extra value to the pipe wall thickness parameter or the liner thickness parameter to take into account the deposition.

(8) Some pipes may have a kind of plastic liner which creates a certain amount of gaps between liner and the inner pipe wall. These gaps could prevent ultrasonic waves from direct traveling. Such conditions will make the measurement very difficult. Whenever possible, try to avoid this kind of pipe. If you have to work on this kind of pipe, we recommend you to use our insertion type transducers that are installed permanently on the pipe by drilling holes on the pipe wall. Refer to Appendix §9.3 for details.

(9) When select the measurement site, you may need to consider where to mount the flowmeter main unit. Normally, the EF12 electronics are housed in a weather-resistant enclosure. It can be mounted in a meter shed, or a location that allows easy access to the flowmeter for programming and servicing.

(10) When select the measurement site, you may also need to consider how to install the transducers. Make sure you have enough space for easy operation.

§2.9 Transducers Wiring

Since the EF12 utilizes balanced topology for high-performance ultrasonic transmitting and receiving, it is recommended to use high-frequency twisted cable with shielding as the transducer cable in order to guarantee the signal quality. Please refer to section §2.2 and Appendix §9.1 on how to wire transducers to the flowmeter terminals.

§2.10 Transducers Installation

The transducers used by the EF12 series ultrasonic flowmeter are made of piezoelectric crystals both for transmitting and receiving ultrasonic signals through the wall of liquid piping system. The measurement is realized by measuring the traveling time difference of the ultrasonic signals. Since the difference is very small, the spacing and the alignment of the transducers are critical factors to the accuracy of the measurement and the performance of the system. Meticulous care should be taken for the installation of the transducers.

Clamp-on transducer installation steps:

(1) Locate an optimal position where the straight pipe length is sufficient (see the previous section), and where pipes are in a favorable condition, e.g., newer pipes with no rust and ease of operation.

(2) Calculate the transducer spacing. Just enter the pipe, fluid and transducer information through menu M11 to M24, the flowmeter will calculate the transducer spacing automatically. The value will be shown in M25. Marking the transducer installation spots on the pipe according to this

spacing value.

(3) Clean any dust and rust on the spot where the transducers are to be installed. For a better result, polishing the pipe outer surface with a sander is strongly recommended.

(4) Apply adequate ultrasonic couplant (grease, gel or Vaseline) onto the transducer surface as well as to the installation area on the pipe surface.

(5) Strap on the transducers using clamp fixture. If the pipe is metal, no need to use clamp fixture since the transducer has magnetic built-in. Make sure there is no gap between the transducer surface and the pipe surface.

(6) Fine tune transducer position until the triplet, signal strength S, signal quality Q and transit-time ratio R, have the best readings and those reading are in their *operational ranges* (S≥60, Q≥60 and 97%≤ R ≤103%). It is even better if you can tune those readings into their *optimal ranges* (S≥80, Q≥80 and 99%≤ R ≤101%). Note, for large velocity flow, the R values may exceed this range to some degree.
You may also need to check the measured liquid sound speed (M92) to see if it is close to the theoretic one of the liquid (you may find this info from a physical handbook if you know the liquid material).

For more details on clamp-on transducer installation, please refer to Appendix §9.2.

For wetted transducer installation, please refer to Appendix §9.3.

§2.11 Installation Checkup

After the completion of transducer installation, the user should check the following three parameters (the triplets): signal strength S, signal quality Q and transit-time ratio R. The triplet values should fall into their range. One may also need to check delta time (traveling time difference between the upstream and the downstream signals), estimated liquid sound speed, and etc. As such, one can be sure that the flowmeter is working properly and the results are reliable and accurate.

§2.11.1 Signal Strength

Signal strength S indicates the amplitude of receiving ultrasonic signals by a 3-digit number. [00.0] means there is no signal detected, and [99.9] refers to the maximum signal strength that can be received. Note that sometimes when no confusion will be introduced, S value is expressed by two digits (00-99) for simplicity.

Although the instrument works well when the signal strength ranges from 60 to 99, stronger signal strength should be pursued, because a stronger signal means a better result. The following methods are recommended to obtain strong signals:

(1) If the current location is not good enough for a stable and reliable flow reading, or if the signal

strength is lower than 60, relocate to a more favorable location.

(2) Try to polish the outer surface of the pipe, and apply more couplant to increase the signal strength.

(3) Tenderly adjust the position of the two transducers, both vertically and horizontally, while checking the signal strength. Stop at the position where the signal strength reaches to maximum. Then, check the transducer spacing to make sure it is the same as or very close to what window M25 shows.

(4) If the installation method is V-method and the pipe is big, you may need to try Z-method in order to get stronger signals.

§2.11.2 Signal Quality

Signal quality is indicated as the Q value in the instrument. A higher Q value would mean a higher Signal to Noise Ratio (SNR), and accordingly a higher degree of accuracy able to be achieved. Under normal pipe condition, the Q value is in the range of 60-99, the higher the better.

Causes for a lower Q value could be:

(1) Interference from other instruments and devices nearby, such as a power frequency transverter which could cause strong interference. Try to relocate the flowmeter to a new place where the interference can be reduced.
(2) Bad sonic coupling between the transducers and the pipe. Try to polish the pipe surface again, clean the surface and apply more couplant, etc.
(3) The selected pipe section is difficult to conduct the measurement. Relocate to a more favorable pipe line.

§2.11.3 Total Transit Time and Delta Time

The total transit time (or traveling time) and the delta time are displayed on menu window M93. They are the primary data for the instrument to calculate the flow rate. Therefore, the measured flow rate will vary as the total transit time and delta time vary.

The total transit time should remain stable or vary in a very small range.

The delta time normally varies less than 20%. If the variation exceeds 20% in either positive or negative direction, there could be certain kinds of problems with the transducer installation. The user should check the installation for sure.

§2.11.4 Transit Time Ratio

Transit-time ratio R is usually used to check whether the transducer installation is good and whether the entered pipe parameters are in consistency with their actual values. If the pipe parameters are

correct and the transducers are installed properly, the transit time ratio should be in the range of 100±3%. Particularly, when the flow is stand-still, the ratio should be very close to 100%. If this range is exceeded, the user should check:

a) If the entered pipe parameters are correct?
b) If the actual spacing of the transducers is the same as or close to what shown on window M25?
c) If the transducer are installed properly in the right direction?
d) If the mounting location is good, if the pipe has changed shape, or if the pipe is too old (i.e., too much corrosion or deposition inside the pipe)?
e) If there is any interference source inside the pipe?
f) If there are other aspects which do not meet the measurement requirements as recommended earlier?

For more tips and help, please visit our technical support site
at: http://www.spiremt.com/enduroflow-series/ef12-solar-powerd-flowmeter.html

3. How To

§3.1 How to check if the instrument works properly

Switch to menu M08 by entering MENU 0 8 keys. If 'R' is displayed on the screen, the instrument is working properly.

If 'E' is displayed, the current loop output is over-ranged. Increasing the range setting in M57 will make the 'E' letter disappear. If you do not use current loop output, you may ignore this error.

If 'Q' is displayed, the frequency output is over-ranged. Increasing the range setting in M69 will make the 'Q' letter disappear. If you do not use frequency output, you may ignore this error.

If 'G' is displayed, the flowmeter is adjusting system gain. This is normal as long as it does not last long.

If 'I' is displayed, there is no signal received. Check if the transducer cables are connected properly and transducers are clamped firmly.

If 'J' is displayed, there is hardware problem. Turn off the power, then, turn on the power again. If the problem remains, refer to Chapter 5 for diagnosis details.

If an 'H' flashes instead, the received signal is poor.

Please refer to Chapter 5 for diagnosis information.

§3.2 How to check the liquid flowing direction

Assume that transducer A is connected to the upstream terminals and transducer B is connected to the downstream terminals.

First, make sure that the instrument works properly.

Then, check the flow rate reading. If the value is positive, the direction of the flow will be from transducer A to B. Otherwise, the flow is from B to A.

§3.3 How to change units systems

Use menu window M30 for the selection of units systems, either English (option 0) or in Metric (option 1).

§3.4 How to select a flow rate unit

Use menu window M31 to select the flow rate unit, use menu window M32 to select the flow totalizer unit.

§3.5 How to use the totalizer multiplier

Use window M33 to select a proper multiplying factor for the totalizers (POS, NEG and NET). Make sure that the rate of the totalizer pulse is not too fast, neither too slow. A speed of several pulses per minute is preferable.

If the totalizer multiplying factor is too small, the output pulse will be very fast and there could be a loss of pulses. The designed minimum pulse period is 500 milliseconds.

If the totalizer multiplying factor is too large, the output pulse will be very slow, which might be a problem if the master device requires fast response.

§3.6 How to turn on / off the totalizers

Use M34, M35 or M36 to turn on or turn off the POS, NEG or NET totalizer, respectively.

§3.7 How to reset the totalizers

Use M37 to reset the flow rate totalizers.

§3.8 How to restore the factory default setups

Go to window M37. Press the [.] [←] Keys. This operation will erase all the parameters entered by the user and setup the instrument with factory default values.

§3.9 How to use the damper to stabilize the flow rate

The damper acts as a filter for a stable reading. Its damping constant is entered in window M40. Its unit is in second. If ‘0’ is entered, that means there is no damping. A bigger constant number brings a more stable effect. But bigger numbers will prevent the instrument from acting quickly.

A constant from 3 to 30 is commonly used for the damper value.

§3.10 How to use the low-flow cutoff function

The value displayed in window M41 is the low-flow cutoff. When the absolute value of the measured flow velocity is below this value, the measured velocity as well as flow rate will be replaced with ‘0’. This is to avoid any invalid accumulation when the actual flow is below the low-flow cutoff value.

Application example: when a pump is shut down, the liquid will not stop immediately. It will keep moving (may be backward) for a little while. During this period, the totalizer should be prevented

from accumulating. This can easily be done by setting the low-flow cutoff velocity to a certain value, such as 0.1ft/s (0.03m/s)

The low-flow cutoff operation does not affect the flow measurement when the actual flow is greater than the low-flow cutoff value.

§3.11 How to conduct Zero calibration

When the flow in a pipe is absolutely stopped, the flowmeter could still give a small non-zero flow rate reading due to transducer installation or pipe-sensor mismatching. In order to make the measurement accurate, it is necessary to remove this “Zero Point” reading.

Window M42 allows us to take care of this issue. At first, the user should make sure that the liquid in the pipe is totally stopped (no velocity). Then, go to window M42 and press the ENT key to start the zero calibration (or zero point setup) function. Wait until the counter reading goes down to ‘00’.

You must then save the Zero Point into the flowmeter non-volatile FLASH memory so that it will not get lost when power is off. This can be done by simply pressing keys MENU . 2.

§3.12 How to change the scale factor

You may change the scale factor in menu window M45. After the change, we recommend you to save the value to the non-volatile FLASH memory. Press keys MENU 2 6 to enter into window M26, then, press ENT 1 ENT to save.

A scale factor is the ratio between the ‘actual flow rate’ and the flow rate measured by the flowmeter. It can be determined by calibration with standard flow calibration equipment. Please go to our technical support site http://www.spiremt.com/enduroflow-series/ef12-solar-powerd-flowmeter.html to see the instructions.

The scale factor is transducer dependent. Prior to shipment from the factory, the scale factor of a transducer pair is calibrated on a pipe with water flow. If you ordered multiple pairs of transducers, be sure you enter the scale factor of the transducer pair you are using. Also, we recommend you to do a Zero calibration (refer to the above section) each time after the transducer change.

The scale factor is also affected by other factors such as pipe size, fluid viscosity, installation variation, etc. It is therefore recommended to do on-site calibration when accuracy is of crucial importance.

§3.13 How to use the password locker

The password locker provides a means of preventing inadvertent configuration changes or totalizer resets. When the system is locked, the user can still browse menu windows, but cannot make any modifications on the windows.

The password locking / unlocking is done in window M47. The system can be locked without a password or with a password consisted of 1 to 4 digits.

For no-password locking / unlocking, just press ENT key in window M47.

If the password is forgotten, please contact the manufacturer.

§3.14 How to use the keypad locker

First, switch to the menu window which will be displayed after the keypad is locked.

Then, press MENU 4 8 to switch to menu M48. Press ENT and enter a 1-8 digit long password. Password should be numerical only. Press ENT again to set the password. The system will return to the previously selected window automatically.

To unlock keypad, press ENT, enter the password, and press ENT again.

§3.15 How to use the scheduler

EF12 has a built-in scheduler which allows user to set a specific period of time to conduct one of the following activities:

- Send data to the internal serial port
- Start to monitor the flowrate, and trigger an alarm if it is over a preset threshold
- Start to accumulate flow, and trigger an alarm if the flow total is over a preset threshold

The first activity is reserved for 4-20mA output, printer and other future extended functions. Data items to be sent to the internal serial port are selected in M50.

The last two activities can be used for leakage detection and scheduled dosing or batching.

The scheduler parameters are set in M51. They include the starting time, time interval and number of times to repeat the activity.

For example, if you want to start the activity at 9.30pm, stop at 11.00pm, and repeat this 50 times, you need to enter the following parameters in M51:

Start Time	21:30:00
Interval	01:30:00
Last	50

The scheduler can be used for leakage detection and timed batch delivery. Please refer to sections §3.32 and §3.35 for more details.

§3.16 How to use 4-20mA current loop output

EF12 has one channel of isolated 4-20mA analog output. The accuracy of this output is better than 0.1%. It can be configured to different mode, such as 4-20mA mode, 0-20mA mode, etc. Mode selection can be made in menu M55. Refer to the next chapter for details on M55.

In order to use the 4-20mA output function, you need to not only select the mode to be 4-20mA in M55, but also set the flow rate values which correspond to the minimum current (4mA) and the maximum current (20mA). Enter the two values in M56 and M57.

Example A: flow rate range is 0-500m3/h. Just enter 0 in M56 and 500 in M57.

Example B: flow rate range is -500-0-1000m3/h. If flow direction is not an issue for you, you may select 20-4-20mA mode in M55. Then, enter 500 in M56 and 1000 in M57. If flow direction is an issue, you may select 0-4-20mA mode in M55. This means that the current loop will output 0-4mA when flow rate is negative and 4-20mA when flow rate is positive. Enter -500 in M56 and 1000 in M57.

You may need to calibrate and test the current loop output before using it. Just go to menu M58 and do the following:

First, connect an ammeter to the current loop output.

Press MENU 5 8, then, ENT to enter into menu M58.

Use ↑/+ and ↓/- to display “0mA”, “4mA”, “8mA”, “16mA”, “20mA” orderly, record the corresponding reading on the ammeter. Calculate the differences between the readings and the selected ones. For instance, when 4mA is selected, the actual output current shown on the ammeter is 4.01mA. Then, the difference is 0.01mA.

If the differences are not within tolerance, calibrate the current loop (see section §3.33.)

The present current loop output is displayed in Window M59. It changes along with flow rate change.

Wiring: There are two ways to wire this analog output to an external device: standard current-loop connection and loop-powered connection (Figure 3.1.) Which connection to use is totally dependent on whether the external device provides 24VDC power to the current-loop. If yes, use the loop-powered connection.

The 0/4-20mA current output actually does not output current. Instead, it sinks

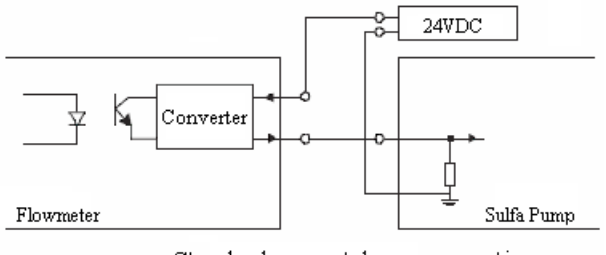


Figure 3.1. Connect the isolated 0/4-20mA analog output to an external device.

current. The minimum sinking current is about 3mA.

§3.17 How to output analog voltage signal

Connect a 250Ohm/0.25W resistor across the AO – and 9-24VDC – terminals. This will convert the 4-20mA current signal into 1-5V voltage signal.

§3.20 How to produce an alarm signal

There is an audible alarm available with this instrument, the audible alarm is also called Buzzer. It is generated internally and can be configured in M77.

The triggering sources of the alarming events for the Buzzer could be:

(0) No Signal - There is no receiving signal.

(1) Poor Signal - The signal received is too weak.

(2) Not Ready - The flowmeter is not in normal measurement mode.

(3) Reverse Flow - The flow direction is reversed.

(4) AO Over 120% - Overflow occurs at the analog outputs by 120% or more.

(5) AO Over 120% - Overflow occurs at the frequency output by 120% or more.

(6) Alarm #1 - The flow rate is out of the specified upper and lower limits specified in Alarm#1 settings (windows M73 and M74).

(7) Alarm #2 - The flow rate is out of the specified upper and lower limits specified in Alarm#2 settings (windows M75 and M76).

(8) Batch Controller – Batching started.

(9) POS Int Pulse – Positive totalizer pulse output.

(10) NEG Int Pulse – Negative totalizer pulse output.

(11) NET Int Pulse – Net totalizer pulse output.

(12) Energy POS Pulse – Thermal energy positive totalizer pulse output.

(13) Energy NEG Pulse – Thermal energy negative totalizer pulse output.

(14) Energy NET Pulse – Thermal energy net totalizer pulse output.

(15) MediaVel => Thresh – Liquid sound speed becomes bigger, over the preset threshold.

(16) MediaVel <= Thresh – Liquid sound speed becomes smaller, lower than the preset threshold.

(17) ON/OFF Via RS485 – RS485 is the trigger source, providing ON/OFF control.

(18) Timer (M51 Daily) –Daily scheduler programmed in M51 is the trigger source.

(19) Timer Alarm #1 – Alarm#1 is the trigger source during the time period specified in M51.

(20) Timer Alarm #2 – Alarm#2 is the trigger source during the time period specified in M51.

(21) Batch Total Full – The totalizer in the batch controller is full.

(22) Key Stroking ON – Key stroke is the trigger source.

(23) Disable BEEPER – the BEEPER will not be activated.

Example A: assume we need the Buzzer to start beeping when the flowmeter is not ready in normal measurement. Switch to M77, select item "2. Abnormal Measurement State"

Example B: assume we need the Buzzer to start beeping when the flow rate is less than 300 m3/h and greater than 2000m3/h. The following setup steps would be recommended:

(1) Enter flow rate lower limit 300 in M73 for #1 alarm,

(2) Enter flow rate upper limit 2000 in M74 for #1 alarm,

(3) Select item '6. Alarm #1' in M77.

§3.23 How to use the built-in Buzzer

The built-in buzzer is user-configurable. It can be used as an alarm. Use M77 for setups.

§3.24 How to modify the built-in calendar

The current date and time is displayed in menu M04 in format "yy-mm-dd hh:mm:ss". If this is the first time you run the flowmeter, please do make sure that the date and time are correct. If not, please make correction. In addition, if "daylight saving" applies in your area, you may also need to change the time accordingly.

To make changes on the date and time, press MENU 6 0 ENT to switch to menu M60 and modify the settings. Use the dot key to skip over these digits that need no modifications.

The calendar can also be modified through the serial port. Please refer to Chapter 6.

Please use M26 to save the modification.

§3.26 How to use the RS485 interface

The EF12 family flowmeters are equipped with a standard half-duplex RS485 serial interface. The terminals for this port are 485+ (A) and 485-(B). Therefore, only two wires are needed to connect a EF12 flowmeter to a RS485 bus. The data rate of the RS485 port can be set to 75-115,200 Baud in M62. The default is 9600. Each flowmeter has a network address which is set to 1 by default. You may change it in M46.

Please refer to Chapter 6 and Appendix §9.1 for more details.

§3.27 How to view and reset the yearly/monthly/daily totalizers

Use M82 to view the daily, monthly and yearly totalized flow and energy. Use M37 to reset.

To view the last 128 days' flow/energy history, press MENU 8 2, then, select item 0 for "Day". You should see a serial number and the date, and the net totalized flow for this specific day. You may use ↑/+ key to see the thermal energy total of that day.

Similarly, to view the flow/energy total for the last 64 months or last 5 years, press MENU 8 2 and select item 1 for "Month" or 2 for "Year ".

Note that, in the result window, you may see "----", which indicates that the system was normal during that day. If you see other characters, such as "H", "G", etc., which indicate that errors occurred in that day. Please refer to chapter 5 for error code explanations and solutions.

§3.29 How to compensate the flow not measured during offline

When the power is down, the flowmeter will not be able to conduct flow measurement. In order to compensate the flow uncounted during the offline period, you need to enable Automatic Amending function before the flowmeter is offline.

To enable the Automatic Amending function, switch to M83, press ENT key, then, select YES and press ENT again.

To disable this function, just select OFF in menu M83.

Please note that there are many factors which could impact the reliability of this function in a complicate application. We do not recommend you to use this function. Instead, try to find an interrupt power supply.

Refer to the next chapter for M83 details and how the uncounted flow is estimated.

§3.30 How to use the Working Timer

Use the working timer to check the time that has passed with a certain kind of operation.

The working timer value is displayed in M72. To reset the timer, press ENT key and select YES.

§3.31 How to use the manual totalizer

Use M38 for the manual totalizer setup. Switch to M38. Press ENT key to start the totalizer, and press ENT key again to stop the totalizer.

This function is useful for conducting flowmeter calibration.

§3.33 How to calibrate the analog output

In general, there is no need to calibrate the analog output since it has been calibrated in factory. However, if you find the current value shown in M58 differs from the actual current shown in the ammeter, you do need to recalibrate the analog output.

Calibration steps:

First, put the flowmeter into calibration mode. Press MENU - 0 ENT, enter password "4213068", and press ENT again.

Then, connect a precise ammeter to the current output loop.

Press MENU - 0 ENT to calibrate the current loop 4mA output. Read the ammeter. If the reading is not 4mA, use ↑/+ or ↓/- to adjust the output current until the ammeter reads 4.00mA.

Press ENT again to calibrate 20mA output, similar to the above step.

Press MENU 2 6 to enter into window M26, press ENT 1 ENT to save the above configuration results into non-volatile memory.

§3.34 How to check the ESN

Each product of the EF12 series has a unique electronic serial number (ESN) to identify itself. The user can use the ESN for instrumentation management.

The ESN is displayed in window M61.

Use M+1 to view the total working time since the instrument left the factory. Use M+4 to view the total number of times the instrument has been turned on and off since the instrument left the factory.

For more application tips and help, please visit our technical support site at:

http://www.spiremt.com/enduroflow-series/ef12-solar-powerd-flowmeter.html

4. Menu Window Details

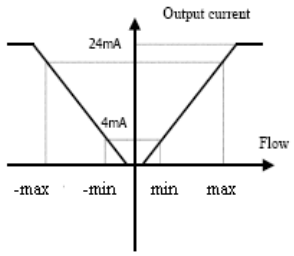
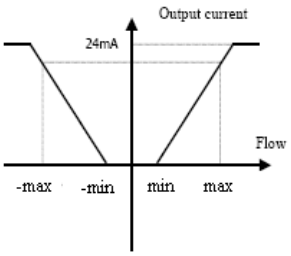
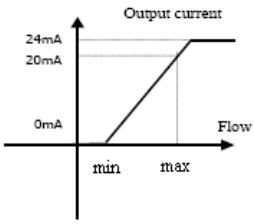
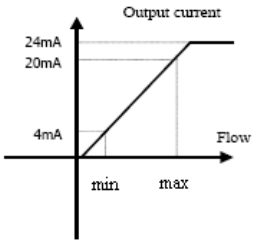
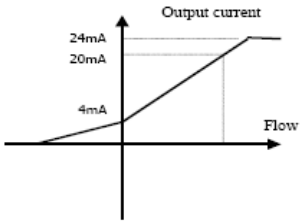
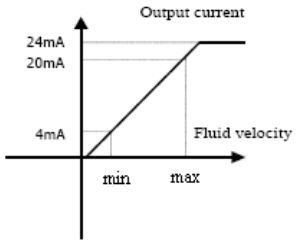
Note 1: To quickly switch to a menu window on EF12 or StufManager™ Key interface, just press MENU followed by the window number (a two digit number). To move from one window to the next, use ↑/+ or ↓/- key.

Note 2: After making changes to the flowmeter configuration parameters, please use M26 to save the changes into the non-volatile FLASH memory. The flowmeter will automatically load those parameters every time when power is up.

Menu Window No.	Function
M00	Display flow rate and net totalizers
M01	Display flow rate, velocity
M02	Display flow rate and positive totalizer
M03	Display flow rate and net totalizer
M04	Display date and time, flow rate
M05	Display total energy and energy rate
M06	Display temperatures, T1 and T2
M07	Display analog inputs AI3 and AI4
M08	Display all the detailed working status
M09	Display today's total flow
M10	Window for entering the outer perimeter of the pipe
M11	Window for entering the outer diameter of the pipe. 0 to 18000mm allowed
M12	Window for entering pipe wall thickness
M13	Window for entering the inner diameter of the pipe
M14	Window for selecting pipe material Standard pipe materials (users do not need to know the speed) include: (0) carbon steel (1) stainless steel (2) cast iron (3) ductile iron (4) copper (5) PVC (6) aluminum (7) asbestos (8) fiberglass (9)others
M15	Window for entering the pipe material speed, only for non-standard pipe materials
M16	Window for selecting the liner material, select none for pipes without any liner. Standard liner materials that the user does not need to know the speed include: (1) Tar Epoxy (2) Rubber (3) Mortar (4) Polypropylene (5) Polystryol (6)Polystyrene (7) Polyester (8) Polyethylene (9) Ebonite (10) Teflon (11) others
M17	Window for entering the liner material speed, only for non-standard liner materials
M18	Window for entering the liner thickness, if there is a liner
M19	Window for entering the ABS thickness of the inside wall of the pipe
M20	Window for selecting fluid type For standard liquids that the user does not need to know the liquid speed include: (0) Water (1) Sea Water (2) Kerosene (3) Gasoline (4) Fuel oil (5) Crude Oil (6) Propane at -45C (7) Butane at 0C (8)Other liquids (9) Diesel Oil (10)Caster Oil (11)Peanut Oil (12) #90 Gasoline (13) #93 Gasoline (14) Alcohol (15) Hot water at 125C

M21	Window for entering the fluid sonic velocity, only for non-standard liquids
M22	Window for entering the viscosity of the non-standard liquids
M23	Window for selecting the proper transducers There are 16 different types of transducers for selection. If the user-type-transducer is selected, system will prompt another 4 user-type-wedge parameters to be inputted. If the PI-type transducer is selected, the system also needs another 4 PI type transducer parameters.
M24	Window for selecting the transducer mounting methods Four methods can be selected: (0) V-method (1) Z-method (2) N-method (3) W-method
M25	Display the transducer mounting spacing
M26	(0) Save the current configuration parameters into RAM. Not recommended for general users (1) Save the current configuration parameters into the non-volatile FLASH memory. Recommended to use this function every time after you make changes on the flowmeter configurations
M27	Entry to store or restore configuration parameters from the internal Flash memory. Up to 9 sets of configuration parameters are allowed.
M28	Select YES or NO for the instrument to determine whether or not to hold (or to keep) the last correct value when poor signal condition occurs. YES is the default setup
M29	Pipe empty setup. Enter a value ranging from 00 to 99. 0 is the default value
M30	Window for selecting unit system. Default value is 'Metric'. The change from English to Metric or vice versa will not affect the totalizer unit.
M31	Window for selecting flow rate that will be used by the instrument afterwards. Flow rate can be in 0. Cubic meter short for (m3) 1. Liter (l) 2. USA gallon (gal) 3. Imperial Gallon (igl) 4. Million USA gallon (mgl) 5. Cubic feet (cf) 6. USA oil Barrels (OB) 7. Imperial Oil Barrels (IB) The flow unit in terms of time can be per day, per hour, per minute, or per second. Thus there are 32 different flow rate units in total for selection.
M32	Window for selecting the totaliziers' working unit
M33	Select totalizer multiplier The multiplier ranges from 0.001 to 10000
M34	Turn on or turn off the NET totalizer
M35	Turn on or turn off the POS totalizer
M36	Turn on or turn off the NEG totalizer
M37	(1) Totalizer reset, including POS/NEG/NET totalizers and Yearly/Monthly/Daily totalizers (2) Restore the instrument to the default parameters as the manufacturer did by pressing the dot key followed by the backspace key. Please take note of the parameters before doing the restoration
M38	Press a key to run or to stop totalizer. Often used for calibration
M39	Language selection
M40	Flow rate damper for a stable value. The input range is 0 to 999 seconds. 0 means there is no damping. Default value is 10 seconds
M41	Lower flow rate cut-off to avoid invalid accumulation.
M42	Zero Point setup or Zero calibration. Should be conducted under the condition when there is no liquid running inside the pipe. After Zeroing, you need to save the Zero Point by pressing keys MENU . 2
M43	Clear the zero point set by the user, and restore the zero point set by the manufacturer
M44	Set up a manual flow trend. In general this value should be 0.
M45	Scale factor for the instrument of certain transducer pair. If you ordered more than one pair of transducers, you need to change the value to the scale factor of

	the transducer pair in use. You are also recommended to do a Zero when change the transducer pair.
M46	Network Environment Identification Number. Any integer can be entered except for 13 (0DH, carriage return), 10 (0AH, line feeding), 42 (2AH), 38, 65535. Every set of the instrument in a network environment should have a unique ID number. Please refer to the chapter on communication.
M47	System locker to avoid modification of the parameters by mistake
M48	Entry to linearity correction data. As many as 12 data points can be entered.
M49	Display the input contents for the serial port.
M50	Turn on/off the data logging port Select the item to be logged to the internal bus, or, to be output through the 0/4-20mA analog output channel. Not recommended to change.
M51	The built-in Scheduler Three parameters: start time, interval and number of times to be repeated.
M52	(1) Data logging direction control. If 'To RS485' is selected, all the data will be transmitted to the RS485 port (2) If 'To the internal serial BUS' is selected, the data will be transmitted to the internal serial bus. If your flowmeter is equipped with a thermal printer or a 4-20mA analog output module, this selection must be chosen. This menu is usually preset in the factory and is not recommended to be changed.
M53	Display the input current value and the converted value of analog input AI5.
M54	Pulse width setup for the OCT output.
M55	Select the current loop (CL) mode. Available options: 0. 4-20mA Output Mode (set up the output range from 4-20mA) 1. 0-20mA Output Mode (set up the output range from 0-20mA) 2. RS232 controls 0-20mA (set up to control by serial port RS485) 3. Turn off the current loop (turn off the current loop to save battery life. Default.) 4. 20-4-20mA Mode (set up the output range from 20-4-20mA) 5. 0-4-20mA Mode (set up the output range from 0-4-20mA) 6. 20-0-20mA Mode (set up the output range from 20-0-20mA) 7. 4-20mA Corresponding Velocity (set up the current loop output range from 4-20mA) 8. 4-20mA Corresponding Heat Flow (set up the current loop output range from 4-20mA) The output current value is controlled by sending a parameterized command to the flowmeter through its RS485 serial port. The command formats are explained in chapter 6. Example, if you want to output a 6mA current through the current loop, you need to select mode "0-20mA Via RS232/485" in menu M55 and send command "A06 (CR)" to the flowmeter. This function allows the flowmeter to control valve openness. Other different current output characteristics are illustrated in the following figures. The user can select one of them according to his actual requirements. The minimum and maximum values indicated in the figure are those set in menu windows M57 and M58. In the 4-20mA and 0-20mA modes, the minimum and maximum can be a positive or negative flow value as long as the two values are not the same. In the 20-4-20mA and 20-0-20mA modes, the polarity of the actual flow reading is ignored. In 0-4-20mA mode, the minimum must be negative, and the maximum must be positive. The last one in the following figures is for velocity output. The output current represents flow velocity.

	 **20-4-20mA Mode**  **20-0-20mA Mode**  **0-20mA Mode**  **4-20mA Mode**  **0-4-20mA Mode**  **4-20mA Mode - Flow Velocity**
M56	4mA or 0mA output value Set the flow rate value which corresponds to 4mA or 0mA output current (4mA or 0mA is determined by the settings in M55). The flow unit options are the same as those in M31. If “velocity 4-20mA” is selected in M55, the unit should be set to m/s.
M57	20mA output value Set the flow rate value which corresponds to 20mA output current. Refer to M31 for flow unit options.
M58	Current loop verification. Check if the current loop has been calibrated before leaving the factory. Press ENT, and use ▼/+ or ▼/- to display 0mA, 4mA - 24mA one after another. For each one, check with an ammeter to verify that current loop output terminals agree with the displayed values. It is necessary to re-calibrate the current loop if over the permitted tolerance. For more information, refer to section §3.29 for analog output calibration.
M59	Display present output of the current loop circuit. Re-calibration is needed if the displayed value differs significantly from the actual output value measured with an ammeter.
M60	Set up system date and time. Press ENT for modification. Use the dot key to skip the digits that need no modification.
M61	Display Version information and Electronic Serial Number (ESN) that are unique for each STUF-300 series flow meter. Users can employ the ESN for instrumentation management
M62	RS485 serial communication setup. Baud rate can be 75 to 115200 bps
M63	Communication protocol selection. Default is MODBUS_ASCII plus TDS7 (EFCP) protocol.
M64	Lower and upper values represented by the lower current (4mA) and upper current (20mA) of input channel AI3
M65	Lower and upper values represented by the lower current (4mA) and upper current (20mA) of input channel AI4
M66	Lower and upper values represented by the lower current (4mA) and upper current (20mA) of input

	channel AI5
M67	Input the frequency range for the frequency output. The biggest range is 0Hz-9999Hz. Default value is 0-1000 Hz
M68	Enter a flow rate value that corresponds to lower frequencies
M69	Enter a flow rate value that corresponds to higher frequencies
M70	LCD display backlight control. The entered value indicates how many seconds the backlight will be on with every key press.
M71	LCD contrast control. The LCD becomes darker or brighter when a value is entered.
M72	Working timer. It can be cleared by pressing ENT key, and then select YES.
M73	Enter lower flow rate value that will trigger the #1 Alarm. There are two virtual alarms in the system. By “virtual” we mean that the user must redirect the output of the alarms by setting up the output hardware in M78 and M77.
M74	Enter the higher flow rate value that will trigger the #1 Alarm.
M75	Enter the lower flow rate value that will trigger the #2 Alarm.
M76	Enter the higher flow rate value that will trigger the #2 Alarm.
M77	Buzzer setup. If a proper input source is selected, the buzzer will beep when the trigger event occurs. The valid trigger sources are: 0. No Signal 1. Poor Signal 2. Not Ready 3. Reverse Flow 4. AO Over 120% 5. FO Over 120% 6. Alarm #1 7. Reverse Alarm #2 8. Batch Controller 9. POS Int Pulse 10. NEG Int Pulse 11. NET Int Pulse 12. Energy POS Pulse 13. Energy NEG Pulse 14. Energy NET Pulse 15. MediaVel => Thresh 16. MediaVelo<Thresh 17. ON/OFF Via RS485 18. Timer(M51 Daily) 19. Timer Alarm #1 20. Timer Alarm #2 21. Batch Total Full 22. Key Stroking ON 23. Disable BEEPER
M78	OCT1 (Open Collector Transistor) output setup By selecting a proper input source, the OCT1 hardware will close when the trigger event occurs 0. No Signal 1. Poor Signal 2. Not Ready 3. Reverse Flow 4. AO Over 120% 5. FO Over 120% 6. Alarm #1 7. Reverse Alarm #2 8. Batch Controller 9. POS Int Pulse 10. NEG Int Pulse 11. NET Int Pulse 12. Energy POS Pulse 13. Energy NEG Pulse 14. Energy NET Pulse 15. MediaVel => Thresh 16. MediaVelo<Thresh 17. ON/OFF Via RS485 18. Timer(M51 Daily) 19. Timer Alarm #1 20. Timer Alarm #2 21. Batch Total Full 22. OCT NET Using

M79	OCT2 output setup. OCT2 is normally used to drive an external relay. By selecting a proper input source, the OCT2 hardware will close when the trigger event occurs. The triggering sources are identical to those for OCT1.
M80	Signal selection for the built-in batch controller 0. Key Pressing 1. Serial Port 2. AI3 Rising Edge 3. AI3 Falling Edge 4. AI4 Rising Edge 5. AI4 Falling Edge 6. AI5 Rising Edge 7. AI5 Falling Edge 8. Timer-periodical 9. Timer-daily
M81	The built-in batch controller
M82	Date totalizer by day, by month and by year
M83	Automatic total flow correction switch
M84	Energy unit selection.
M85	Temperature selection
M86	Specific Heat selection
M87	Energy totalizer switch
M88	Energy multiplier
M89	Displays the current temperature difference (T1 - T2)
M90	Display signal strength and signal quality UP – upstream direction; DN – downstream direction; Q – signal quality.
M91	Displays the transit-time ratio between the measured one and the calculated one. If the pipe and liquid parameters are entered correctly and the transducers are properly installed, the ratio value R should be in the range of 100±3%. Otherwise the entered parameters and the transducer installation should be checked.
M92	Displays the estimated fluid sound velocity. If this value has an obvious difference from the actual fluid sound speed, pipe parameters and the transducer installation should be checked again.
M93	Displays total transit time and delta time (transit time difference)
M94	Displays the Reynolds number and the pipe factor used by the flow rate program.
M95	(1) Display the positive and negative energy totalizer values and other menus in a loop fashion: M95->M00-M01->…M09->M90->95. Each menu is displayed for 8seconds. The loop-displaying will stop when any key is pressed.
M96	Reserved for printer
M97	Reserved for printer
M98	Reserved for printer
M99	Reserved for printer
M+0	Browse the 128 recorded instrument power-on and power-off dates and times with the flow rate at the time of power on and off

M+1	Displays the total work time of the instrument
M+2	Displays the last power-off date and time
M+3	Displays the last power-off flow rate
M+4	Displays how many times the instrument has been powered on
M+5	Calculator for the convenience of field working. All the values are in single accuracy.
M+6	MediaVel Threshhold setup (threshold for liquid sound speed)
M+7	Displays total flow for this month (up to today)
M+8	Displays total flow for this year (up to today)
M+9	Total time the flowmeter has not been in normal working mode. It includes the time when power is off.
M.2	Save Zero Point to the non-volatile FLASH memory. When a Zero calibration is done, you are recommended to save the Zero Point results by visiting this menu.
M.8	The maximum flow rates for today and for the current month.
M-0	Entry to hardware adjusting windows only for the manufacturer

5. Troubleshooting

§5.1 Introduction

The EF12 series flowmeters utilized high-reliability design, thus, their malfunction probability is quite low. However, due to improper settings, harsh environment or misusage, problem could occur. Therefore, EF12 is equipped with a complete set of self-diagnosis functions. The errors are displayed in the upper right corner of the menu window via identification code in a timely order. Hardware self-diagnosis is conducted every time when power is on. Some errors can even be detected during normal operation. For those errors undetectable due to incorrect settings or improper testing conditions, the flowmeter will also display useful information to help the user to quickly debug the error and solve the problem.

There are two types of errors, one is hardware error, and the other is operational error. Details are presented in the following sections.

§5.2 Power-on Errors

When powered on, the EF12 series ultrasonic flowmeter automatically starts the self-diagnosis process to find if there are any hardware and software problems. If a problem is identified, an error message will be displayed. The following table shows the possible error messages, the corresponding causes and their solutions.

Table 5.1 Hardware self-diagnosis errors and solutions

Error message	Causes	Solutions
ROM Parity Error	ROM operation illegal / error	(1) Reboot the system (2) Contact the manufacturer.
Stored Data Error	User-entered parameters lost.	(1) Reboot the system (2) If problem persists, press ENT key to restore the factory default configuration.
SCPU Fatal Error	SCPU hardware fatal error	(1) Reboot the system (2) Contact the manufacturer.
System Clock Slow or Fast Error	Problem with the system clock or the crystal oscillator.	
CPU or IRQ Error	Problem with CPU or IRQ hardware	
System RAM Error	Problem with RAM chip	

Time Date Error	Problem with date/time chip	(1) Initialize the calendar in menu window M61. (2) Contact the manufacturer.
No Display. Erratic or Abnormal Operation	Problem with wiring	Double check wiring connections.
No response to key pressing	Keypad is locked Bad plug connection	Unlock the keypad.
Reboot repetitively	Hardware problems	Contact the manufacturer

§5.3 Working Status Errors

The EF12 series ultrasonic flowmeter will show an Error Status Code in its local LCD display. If you use external StufManager™ software, the error code will be shown differently. When any abnormal Error Code shows, counter-measures should be taken.

§5.3.1 Error Codes on Local LCD

The status of the flow meter is shown in display item 07. The display pattern is

FxG SS Q

Where

SS is the signal strength. In normal working condition, it should be in range 50~99. The bigger the better

Q is the signal quality. In normal working condition, it should be in 5~9. The bigger the better

G is normally a space character. However, during signal adjusting process, it shows which step the adjusting is at.

x stands for the error code:

"-" Normal state, equal to 'R'

"1" signal lower

"2" poor signal

"3" pipe empty

"4" hardware error(s)

"5" In signal adjusting

"6" Overflow at Frequency Output

"7" Over-range for the Analog Output

"8" Checksum error of internal data

"9" clock or calendar error(s)

“A” Parameter checksum error

“b” Software checksum error

“C” Temperature circuits error

“d” Reserved

“E” Internal timer over flow

“F” Analog Inputs over range error

If there exist more than one error codes by the same time, the error codes will be displayed one after another within a few seconds.

If you see an error occurred, please refer to the next table for the possible solutions.

§5.3.2 Error Codes on Auxiliary Interface

On the StufManager^{TM}’s Key menu, the error code is displayed on the upper right corner of a menu window or can be viewed in menu M08.

Table 5.2(b) Working status errors and solutions

Error code	Message on window M08	Causes	Solutions
R	System Normal	No error	
I	No Signal	(1)Unable to receive signal (2)Transducers installed improperly (3)Loosen contact or not enough couplant between transducer and pipe surface. (4)Pipe liners are too thick or the deposition inside of the pipe is too thick. (5)Transducer cables are not properly connected	(1)Polish the pipe surface and clean the spot. Remove paint. (2)Make sure the couplant is adequate (3)Make sure the transducer is in tight contact with pipe surface (4)Check the transducer cables (5)Check installation parameter settings (6)Find a better measurement site. Newer pipe, no corrosion, no deposition
J	Hardware Error	Hardware problem	Contact the manufacturer
H	Poor Sig. Detected	Poor signal detected Similar to error code I	Similar to error code I
E	Current Loop Over 20mA	4-20mA loop output over 120% Improper settings for current loop output	(1) Ignore it if current loop output is not used (2) Check current loop settings in M56. (3) Confirm if the actual flow rate is too

			high.
Q	Frequency Output Over	(1) The frequency output is 120% over. (2) Improper settings for frequency output (3) The actual flow rate is too high	(1) Ignore it if frequency output is not used (2) Check the values entered in window M66, M67, M68 and M69. (3) Use a larger value in M69 if needed. (4) Confirm if the actual flow rate is too high.
F	System RAM Error Date Time Error CPU or IRQ Error ROM Parity Error	(1) Temporary problems with RAM, RTC (2) Permanent problems with hardware	(1) Reboot the system (2) Contact the manufacturer Refer to Table 5.1 as well
G	Adjusting Gain >s1 Adjusting Gain >s2 Adjusting Gain >s3 Adjusting Gain >s4 (shown in M00-M03)	Instrument is in the progress of adjusting the gain for the signal, and the number indicates the progressive steps	No need for action
K	Empty pipe	(1) No liquid inside the pipe (2) Incorrect setup in M29	(1) If the pipe is not full, relocate the meter to where the pipe is full of liquid (2) If the pipe is full, enter 0 in M29

§5.4 Other Problems and Solutions

(1) Q: Why the instrument displays 0.0000 flow rate while the liquid in the pipe is actually flowing? The signal strength is checked to be good (the working status is “R”) and the signal quality Q has a satisfactory value.

A: The problem is likely to be caused by the incorrect “Zero Point” setting. The user may have conducted the “Zero Point” setup while the flow was not standstill. To solve this problem, use the ‘Reset Zero’ function in menu window M43 to clear the zero point.

(2) Q: The displayed flow rate is much lower or much higher than the actual flow rate in the pipe under normal working conditions. Why?

A: The entered offset value might be wrong. Enter ‘0’ offset in window M44.

(a) Incorrect transducer installation. Re-install the transducers carefully.

(b) The ‘Zero Point’ is wrong. Go to window M42 and redo the “Zero Point” setup. Make sure that the flow inside the pipe is standstill. No velocity is allowed during this setup process.

(3) Q: Why there is no signal? The installation requirements are met, pipe is new and pipe material is in good quality.

A: Check the following:

(a) Is the installation method suitable for your pipe size?

(b) Are the entered installation parameters correct?

(c) Are the wirings correct?

(d) Adequate couplant? Are the transducers in good contact with pipe?

(e) Is pipe full?

(f) Is the transducer distance in consistency with the one shown in M25?

(g) Is transducer head/tail in the right direction?

(4) Q: How to conduct measurement on an old pipe? Heavy scale inside, no signal or poor signal detected.

A: (a) Check if the pipe is full of liquid.

(b) Try Z method. If the pipe is close to a wall and it is hard to do Z-method installation, you may work on a vertical or inclined pipe with flow upwards.

(c) Carefully select a good pipe section and fully polish/clean the installation area of the pipe surface. Apply a wide band of couplant on each transducer face. Install the transducer properly.

(d) Slowly and slightly move each transducer with respect to each other around the installation point until the maximum signal is found. Be careful that the new installation location is free of scale inside the pipe and that the pipe is concentric (not distorted) so that the sound waves do not bounce outside of the proposed area.

(e) For pipe with thick scale inside or outside, try to clean the scale off, if it is accessible from the inside. (Note: Sometimes this method might not work and sound wave transmission is not possible because of the layer of scale between the transducers and pipe inside wall).

(5) Q: Why no current in the current loop output?

A: Check if the current output mode is set correct in M55. You need to turn the current loop on in M55. Check the hardware connection: open the electronics enclosure, check to see if wires are properly connected.

(6) Q: Why is the current output not correct?

A: (a) Check if the current output mode is set correct in M55.

(b) Check the upper and lower current settings in M56 and M57.

(c) Re-calibrate the current loop. Verify the output with M49.

(7) Q: Can the flowmeter work normally for a few years without stop under harsh environment where power supply voltage varies widely?

A: Yes. EF12 flowmeter employed intelligent signal processing algorithms to handle strong interference coming from either power line or radiation. It also automatically adjusts itself to the

optimal operation status when sound wave strength varies due to changing environment.

Please go to our technical support website for the latest application and solution tips,
http://www.spiremt.com/enduroflow-series/ef12-solar-powerd-flowmeter.html

6. Communication Protocol

§6.1 General

The EF12 series ultrasonic flowmeter has integrated a standard isolated RS485 communication interface to allow the flowmeter to be easily connected to a RS485 network bus. The RS485 interface is a two-wire, half-duplex serial interface, supporting MODBUS protocol as well as Spire Metering's Extended Flowmeter Communication Protocol (EFCP). MODBUS is a common industrial communication protocol. It comes with two formats, MODBUS-ASCII and MODBUS-RTU. Both are supported by EF12.

You may also use our GSM/GPRS module to transmit flow data to a remote computer. With the GSM/GPRS module, you are even able to check the flow data and flowmeter status from your cell phone.

When using the flowmeter for networking, you may use the flowmeter's network ID as its network address, and use [W]-extended command set as the communication protocol. The 4-20mA current loop output can be used to control analog-based or stepper-based valve openness.

The maximum transmission distance is 1000m for RS485. If longer distance is needed, current loop, MODEM, GSM/GPRS can serve the purpose.

All the flowmeter operations can be made on a remote computer, except the modification of the network ID which can only be done locally through an auxiliary interface such as StufManager^{TM} software. The communication protocol is based on master-slave principle. Master (remote computer) sends a command, slave (the flowmeter) responses the command.

You may use the Hyper Terminal utility in your computer to send commands to and view responses from the flowmeter. Please refer to your computer's manual on how to configure the Hyper Terminal utility. Note that the COM port settings of your computer need to match those in the flowmeter (M62.)

By default, the RS485 will be setup with 9600, none, 8, 1 (9600 Baud， none parity, 8 data bits，1 stop bit).

You may also use Spire Metering's StufManager^{TM} software for the same purpose. Please check our website for latest software release.

§6.2 RS485 Wiring

If your master unit (a computer, a PLC or other controllers) does not have a RS485 port, you need to buy a RS485-RS232 converter or a RS485-USB converter in order to connect your EF12 main unit to the master unit.
The figure in Appendix §9.1 illustrates an example of a flowmeter network based on RS485 bus. The 120Ohm resistor is recommended to be connected at the end of the bus if the length of the wires is long. If you simply connect the flowmeter to your PC though a 485 converter, you do not need to have this resistor.

To complete the wiring, follow those steps:

- Disconnect the main power to the unit and remove the cover.
- Install the required cable clamp in the chosen conduit hole on the side of the electronics enclosure.
- Feed one end of the cable through the conduit hole, wire it to terminal pins 485+ and 485-, then, secure the cable clamp. Connect the other end of the cable to the 485 converter.
- Wire the 485 converter according to the its instructions
- Reinstall the rear cover on the enclosure and tighten the set screw.

Please refer to Appendix §9.1 for more information.

§6.3 MODBUS Protocol

Both MODBUS -ASCII and MODBUS -RTU protocols are supported. You may use menu window 63 (M63 hereafter) to select which protocol to use. The default is MODBUS-ASCII protocol.

Amount all the MODBUS functions, only function code 03, code 06 and code 16 are supported. Code 03 and code 06 are used to read from and write to a single register, and code 16 is used to write a block of registers. With RTU protocol, the maximum number of registers can be read at one time is 125, but with ASCII protocol, this maximum number is 61 only.

Example 1: we want to use MODBUS –RTU protocol to read flow velocity (REG 5 and REG 6) from flowmeter unit #1.

Select MODBUS-RTU in M63. Send the following command to RS485 bus where flowmeter unit#1 is connected:

01	**03**	**00 04**	**00 02**	**85 CA (Hex)**
Unit#	Function Code	Start REG	# of REGs	Check-sum

Here 85 CA is the hex value of the check-sum, which is calculated according to CRC-16 (BISYNCH, polynomial $x^{16} + x^{15} + x^2 + 1$, logical exclusive word 0A001H). Please refer to MODBUS standards for details.

The response to the above command will be (assume velocity is 1.2345678m/s):

01 03 04 06 51 3F 9E 3B 32 (Hex)

Unit# Function Code # of bytes Velocity Data Check-sum

Here 3F 9E 06 51 represents velocity data 1.2345678, single-precision float format.

Example 2: we want to use MODBUS –RTU protocol to read net flow total (REG 25 and REG 26) from flowmeter unit #1.

Select MODBUS-RTU in M63. Send the following command to RS485 bus where flowmeter unit#1 is connected:

01 03 00 18 00 02 44 0C (Hex)

Unit# Function Code Start REG # of REGs Check-sum

The response to the above command will be (assume the net total is 802609, i.e., 00 0C 3F 31 in hex):

01 03 04 3F 31 00 0C A7 ED (Hex)

Unit# Function Code # of bytes Velocity Data Check-sum

Please pay attention to the order of data.

Example 3: we want to use MODBUS –ASCII protocol to read REG 1 to REG 10 from flowmeter unit #1.

Select MODBUS-ASCII in M63. Send the following command to RS485 bus where flowmeter unit#1 is connected:

:01030000000AF2 (CR and LF)

Here ":" is the lead character of the MODBUS-ASCII protocol, "F2" is a two bytes checksum, computed by binary summing the ASCII code of all the characters before the checksum byte but not include the lead character.

Note: When debug the MODBUS protocol code, you may use MODSCAN tool which is free and can be downloaded from website.

§6.3.1 MODBUS REGISTERS TABLE

MODBUS REGISTERS TABLE for EF12

REGISTER	NUMBER	VARIABLE NAME	FORMAT	NOTE
0001-0002	2	Flow Rate	REAL4	In unit m3/h
0003-0004	2	Energy Flow Rate	REAL4	In unit: GJ/h
0005-0006	2	Velocity	REAL4	In unit: m/s
0007-0008	2	Fluid sound speed	REAL4	In unit: m/s
0009-0010	2	Positive accumulator	LONG	All long integer flow accumulators' units are controlled by M32 (REG1438), lower byte first
0011-0012	2	Positive decimal fraction	REAL4	REAL4 is a format of Singular, IEEE-754 number, also called FLOAT
0013-0014	2	Negative accumulator	LONG	
0015-0016	2	Negative decimal fraction	REAL4	
0017-0018	2	Positive energy accumulator	LONG	All long integer energy accumulators' units are controlled by M32 (REG1438)
0019-0020	2	Positive energy decimal fraction	REAL4	
0021-0022	2	Negative energy accumulator	LONG	
0023-0024	2	Negative energy decimal fraction	REAL4	
0025-0026	2	Net accumulator	LONG	
0027-0028	2	Net decimal fraction	REAL4	
0029-0030	2	Net energy accumulator	LONG	
0031-0032	2	Net energy decimal fraction	REAL4	
0033-0034	2	Temperature #1/inlet	REAL4	In unit DegC
0035-0036	2	Temperature #2/outlet	REAL4	In unit DegC
0037-0038	2	Analog input AI3	REAL4	
0039-0040	2	Analog input AI4	REAL4	
0041-0042	2	Analog input AI5	REAL4	
0043-0044	2	Current input at AI3	REAL4	In unit mA
0045-0046	2	Current input at AI4	REAL4	In unit mA
0047-0048	2	Current input at AI5	REAL4	In unit mA
0049-0050	2	System password	BCD	Writable. 00H for unlock
0051	1	Password for hardware	BCD	Writable. "A55Ah" for unlock
0053-0055	3	Calendar (date and time)	BCD	Writable. 6 Bytes of BCD stands SMHDMY , lower byte first
0056	1	Day+Hour for Auto-Save	BCD	Writable. For example 0512H stands Auto-save

				on 12:00 on 5th. 0012H for 12:00 on everyday.
0059	1	Key to input	INTEGER	Writable
0060	1	Go to Window #	INTEGER	Writable
0061	1	LCD Back-lit lights for	INTEGER	Writable. In seconds
0062	1	Times for the beeper	INTEGER	Writable. Max 255
0062	1	Pulses left for OCT	INTEGER	Writable. Max 65535
0072	1	Error Code	BIT	16 bits, see note 4
0077-0078	2	PT100 resistance of inlet	REAL4	In unit Ohm
0079-0080	2	PT100 resistance of outlet	REAL4	In unit Ohm
0081-0082	2	Total travel time	REAL4	In unit Micro-second
0083-0084	2	Delta travel time	REAL4	In unit Nino-second
0085-0086	2	Upstream travel time	REAL4	In unit Micro-second
0087-0088	2	Downstream travel time	REAL4	In unit Micro-second
0089-0090	2	Output current	REAL4	In unit mA
0092	1	Working step and Signal Quality	INTEGER	High byte is for the step and low byte is for the signal quality (00-99，the larger the better.)
0093	1	Upstream strength	INTEGER	Range 0-4095
0094	1	Downstream strength	INTEGER	Range 0-4095
0096	1	Language used in user interface	INTEGER	0 : English，1:Chinese
0097-0098	2	Rate of measured travel time by calculation.	REAL4	Normal 100+-3%
0099-0100	2	Reynolds number	REAL4	
0101-0102	2	Pipe Reynolds factor	REAL4	
0103-0104	2	Working Timer	LONG	unassigned，in seconds
0105-0106	2	Total working time	LONG	unassigned，in seconds
0105-0106	2	Total power on-off time	LONG	unassigned
0113-0114	2	Net accumulator	REAL4	In Cubic Meter，float
0115-0116	2	Positive accumulator	REAL4	In Cubic Meter，float
0117-0118	2	Negative accumulator	REAL4	In Cubic Meter，float
0119-0120	2	Net energy accumulator	REAL4	In Cubic Meter，float
0121-0122	2	Positive energy accumulator	REAL4	In Cubic Meter，float

0123-0124	2	Negative energy accumulator	REAL4	In Cubic Meter，float
0125-0126	2	Flow for today	REAL4	In Cubic Meter，float
0127-0128	2	Flow for this month	REAL4	In Cubic Meter，float
0129-0130	2	Manual accumulator	LONG	
0131-0132	2	Manual accumulator decimal fraction	REAL4	
0133-0134	2	Batch accumulator	LONG	
0135-0136	2	Batch accumulator decimal fraction	REAL4	
0137-0138	2	Flow for today	LONG	
0139-0140	2	Flow for today, decimal fraction	REAL4	
0141-0142	2	Flow for this month	LONG	
0143-0144	2	Flow for this month, decimal fraction	REAL4	
0145-0146	2	Flow for this year	LONG	
0147-0148	2	Flow for this year, decimal fraction	REAL4	
0158	1	Current window	INTEGER	
0165-0166	2	Failure time	LONG	In seconds
0173-0174	2	Current output frequency	REAL4	In Hz
0175-0176	2	Current output with 4-20mA	REAL4	In mA
0181-0182	2	Temperature difference	REAL4	In DegC
0183-0184	2	Lost flow	REAL4	In Cubic Meter
0185-0186	2	Clock coefficient	REAL4	Should be less than 0.1
0187-0188	2	Total time for Auto-Save	LONG	Time to save by 0056
0189-0190	2	POS flow for Auto-Save	REAL4	Time to save by 0056
0191-0192	2	Flow rate for Auto-Save	REAL4	Time to save by 0056
0221-0222	2	Inner pipe diameter	REAL4	In millimeters
0229-0230	2	Upstream delay	REAL4	In microseconds
0231-0232	2	Downstream delay	REAL4	In microseconds
0233-0234	2	Calculated travel time	REAL4	In microseconds
0257-0288	32	LCD buffer	BCD	Readable
0289	1	LCD buffer pointer	INTEGER	
0311	2	Time worked for today	LONG	Unassigned, in seconds
0313	2	Time worked for this	LONG	Unassigned, in seconds

		month		
0315	2	Maximum flow for today	INTEGER	In m3/h
0317	2	Maximum flow for this month	INTEGER	In m3/h
1437	1	Unit for flow rate	INTEGER	Range 0-31 See note 5
1438	1	Unit for flow totalizer	INTEGER	Range 0-7, See note 1
1439	1	Multiplier for accumulator	INTEGER	Range 0-7, see note 1
1440	1	Multiplier for energy accumulator	INTEGER	Range 0-10, see note 1
1441	1	Unit for energy totalizer	INTEGER	Range 0-3, 0=GJ, 1=Kcal, 2=KWh, 3=BTU
1442	1	Device address	INTEGER	
1491	1	Device Type	INTEGER	BIT0=0 flow meter BIT0=1 Energy meter BIT3=1 Energy meter install in the flow inlet BIT3=0 Energy meter install in the flow outlet
1451	2	User scale factor	REAL4	
1521	2	Manufacturer scale factor	REAL4	Read only
1529	2	Electronic serial number	BCD	High byte first

Note: (1) The internal totalizer is been presented by a LONG number for the integer part together with a REAL number for the decimal fraction. In general uses, only the integer part needs to be read. Reading of the fraction can be omitted. The final totalizer result has a relation with unit and multiplier. Assume N stands for the integer part (for the positive accumulator, the integer part is the content of REG 0009, 0010, a 32-bits signed LONG integer,), Nf stands for the decimal fraction part (for the positive totalizer, the fraction part is the content of REG 0011, 0012, a 32-bits REAL float number,). N stands for the flow multiplier (REG 1439).

The final positive flow rate=(N+Nf) $\times 10^{n-3}$ (in unit decided by REG 1439).

The meaning of REG 1439 which has a range of 0~7 is as following:

0	cubic meter	(m3)
1	liter	(L)
2	American gallon	(GAL)
3	imperial gallon	(IGL)
4	American million gallon	(MGL)
5	Cubic feet	(CF)
6	American oil barrel	(1 barrel =42gallon) (OB)
7	Imperial oil barrel	(IB)

While

The energy flow rate =(N+Nf)$\times 10^{n-4}$ (unit decided by REG 1440) .

(2) Other variables are not given here. Call us if you have the need.

(3) Please note that many of the data items in the above table are for energy measurement. For users who are interested in flow measurement only, please ignore those items.

（4）Error code

Bit0 no received signal
Bit1 low received signal
Bit2 poor received signal
Bit3 pipe empty
Bit4 hardware failure
Bit5 receiving circuits gain in adjustment
Bit6 frequency at the frequency output over flow
Bit7 current at 4-20mA over flow
Bit8 RAM check-sum error
Bit9 main clock or timer clock error
Bit10 parameters check-sum error
Bit11 ROM check-sum error
Bit12 temperature circuits error
Bit13 reserved
Bit14 internal timer over flow
Bit15 analog input over range

Please override these energy-related bits first when in flow-only measurement.

（5）Unit code for flow rate

0	Cubic meter/second	1	Cubic meter/minute	2	Cubic meter /hour	3	Cubic meter /day
4	liter/second	5	liter /minute	6	liter /hour	7	liter /day
8	American gallon/second	9	American gallon /minute	10	American gallon /hour	11	American gallon /day
12	Imperial gallon/second	13	Imperial gallon/minute	14	Imperial gallon/hour	15	Imperial gallon/day
16	American million gallon/second	17	American million gallon/minute	18	American million gallon/hour	19	American million gallon/day
20	Cubic feet/second	21	Cubic feet/minute	22	Cubic feet/hour	23	Cubic feet/day
24	American oil barrel/second	25	American oil barrel/minute	26	American oil barrel/hour	27	American oil barrel/day
28	Imperial oil barrel/second	29	Imperial oil barrel/minute	30	Imperial oil barrel/hour	31	Imperial oil barrel/day

§6.3.2 REGISTER TABLE for the DATE totalizers

（1） REGISTER for totalizers by day

Totalizer data for every past day are stored in a loop queue. Each day has 32 bytes of data and there are 512 days in total. The current pointer which has a range of 0~511 for the day is in REG 0162. If the pointer decreases by 1 when the pointer is 0, then the new pointer value will be 511. Assuming REG 0162= 1, the data for yesterday are in REG 10257~10272, the data for the day before yesterday are in REG10241-10256, and the data for two days ago are in REG 18417-18432.

REGISTER TABLE for the DAY totalizers

block No	Register	number	variable	format	note
n/a	0162	1	Data pointer	Integer	Range: 0~127
	10241	1	Day and Error Code	BCD	Day in high byte
	10242	1	Month and year	BCD	Year in high byte
0	10243-10244	2	Total working time	LONG	
	10245-10246	2	Net total flow for the day	REAL4	
	10247-10248	2	Net total energy for the day	REAL4	
	10249-10250	2	Positive totalizer	LONG	Value of the totalizer at 23:59:59
	10251-10252	2	Negative totalizer	LONG	Value of the totalizer at 23:59:59
	10253-10254	2	Positive energy totalizer	LONG	Value of the totalizer at 23:59:59
	10255-10256	2	Negative energy totalizer	LONG	Value of the totalizer at 23:59:59
	10257	1	Day and Error Code	BCD	Day in high byte
	10258	1	Month and year	BCD	Year in high byte
1	10259-10260	2	Total working time	LONG	
	10261-10262	2	Net total flow for the day	REAL4	
	10263-10264	2	Net total energy for the day	REAL4	
	10265-10266	2	Positive totalizer	LONG	Value of the totalizer at 23:59:59
	10267-10268	2	Negative totalizer	LONG	Value of the totalizer at 23:59:59
	10269-10270	2	Positive energy totalizer	LONG	Value of the totalizer at 23:59:59
	10271-10272	2	Negative energy totalizer	LONG	Value of the totalizer at 23:59:59
…	……	……	……	……	……
511	18417-18432	16			Data block No.511

Note：1. Please refer to the previous section for the error code. 2. 0FFH means register empty.

（2） REGISTER for totalizers by month

The structure of month totalizers is the same as that of the day totalizers. Please refer to related paragraphs. The difference is that there are only 128 data blocks for the month accumulator, and the day variable always has a value of 0.

REGISTER TABLE for the month accumulators

block No	Register	number	Variable	format	note
n/a	0163	1	Data pointer for the month	Integer	Range: 0~127
	8194	1	Error Code	BCD	
0	2818	1	Month and year	BCD	Year in high byte
	8195-8196	2	Total working time	LONG	
	1897-8198	2	Net total flow for the month	REAL4	
	8199-8200	2	Net total energy for the month	REAL4	
	8201-8202	2	Positive totalizer	LONG	Value of the totalizer at the last second in this month
	8203-8204	2	Negative totalizer	LONG	Value of the totalizer at the last second in this month
	8205-8206	2	Positive energy totalizer	LONG	Value of the totalizer at the last second in this month
	8207-8208	2	Negative energy totalizer	LONG	Value of the totalizer at the last second in this month
	8209	1	Error Code	BCD	
	8210	1	Month and year	BCD	Year in high byte
1	8211-8212	2	Total working time	LONG	
	8213-8214	2	Net total flow for the month	REAL4	
	8213-8214	2	Net total energy for the month	REAL4	
	8215-8216	2	Positive totalizer	LONG	Value of the totalizer at the last second in this month
	8217-8218	2	Negative totalizer	LONG	Value of the totalizer at the last second in this month
	8219-8220	2	Positive energy totalizer	LONG	Value of the totalizer at the last second in this month

	8221-8222	2	Negative energy totalizer	LONG	Value of the totalizer at the last second in this month
…	……	……	……	……	……
127	10225-10240	16			Data block No. 127

（3） There is no direct data for the year. Data for the year could be conducted from the data of the months.

§6.3.3 REGISTERS for power-on and power-off

With every power-on and power-off, the new generation flow meter will record data about the time, duration, statue byte and the flow rate into a data block. Every data block consists 32 bytes of data. As many as 32 blocks of data can be recorded for 32 times of power-on and 32 times of power-off. The data blocks are in the structure of a loop queue. The 33rd data block will override the first block by default. The location of the current block is presented in the data pointer. For the current power-on data block, the pointer should be the current pointer minus 1.

MODBUS registers table for the power-on and power-off.

block No	Register	No.	Variable	format	note
n/a	0164	1	Pointer	Integer	Range:0~31
	6145	1	Power-on seconds and minutes	BCD	Seconds in low byte, minutes in high
0	6146	1	Power-on hours and days	BCD	Hours in low byte, days in high
	6147	1	Power-on months and years	BCD	Months in low byte, years in high
	6148	1	Power-on error codes	BIT	B13 stands for corrected lost flow.
	6149	1	Power-off seconds and minutes	BCD	Seconds in low byte, minutes in high
	6150	1	Power-off hours and days	BCD	Hours in low byte, days in high
	6151	1	Power-off months and years	BCD	Months in low byte, years in high
	6152	1	Power-off error codes	BIT	B15 stands for corrected lost flow
	6153	1	Current window No.	Integer	Main menu No. when power off in low byte, Local LCD menu No. in high byte
	6154	1	Total power on off times	Integer	
	6155-6156	2	The total working time	LONG	Unit in second
	6157-6158	2	Positive totalizer	LONG	Unit depends on M32, M33
	6159-6160	2	Positive totalizer decimal fraction	REAL4	Unit depends on M32, M33
	6161-6162	2	Negative totalizer	LONG	Unit depends on M32, M33
	6163-6164	2	Negative totalizer decimal fraction	REAL4	Unit depends on M32, M33

	6165-6166	2	Positive energy totalizer	LONG	Unit depends on M32, M33
	6167-6168	2	Positive energy totalizer decimal fraction	REAL4	Unit depends on M32, M33
	6169-6170	2	Negative energy totalizer	LONG	Unit depends on M32, M33
	6171-6172	2	Negative energy totalizer decimal fraction	REAL4	Unit depends on M32, M33
	6173-6174	2	Net totalizer	LONG	Unit depends on M32, M33
	6175-6176	2	Net totalizer decimal fraction	REAL4	Unit depends on M32, M33
	6177-6178	2	Net energy totalizer	LONG	Unit depends on M32, M33
	6179-6180	2	Net energy totalizer decimal fraction	REAL4	Unit depends on M32, M33
	6181-6182	2	Flow for this day	LONG	Unit depends on M32, M33
	6183-6184	2	Flow for this day decimal fraction	REAL4	Unit depends on M32, M33
	6185-6186	2	Flow for this month	LONG	Unit depends on M32, M33
	6187-6188	2	Flow for this month decimal fraction	REAL4	Unit depends on M32, M33
	6189-6190	2	Flow for this year	LONG	Unit depends on M32, M33
	6191-6192	2	Flow for this year decimal fraction	REAL4	Unit depends on M32, M33
	6193-6194	2	Flow rate when power off	REAL4	Unit in m3/s
	6195-6196	2	Error worked time	LONG	Unit in second
	6197-6198	2	Time worked for today	LONG	Unit in second
	6199-6200	2	Time worked for this month	LONG	Unit in second
	6201-6202	2	M47 password	BCD	
	6203-6204	2	Time duration when off	LONG	Unit in second
	6205-6206	2	Flow rate when power on	REAL4	Unit in m3/s
	6107-6208	2	Corrected lost flow when off	REAL4	Unit in cubic meter
1	6209-6272	64			The 2nd data block
2	6273-7336	64			The 3rd data block
…	… …	…		… …	…… …… …… ……
31	8129-8192	64			The 32nd data block

§6.4 Extended Flowmeter Communication Protocol (EFCP)

The EF12 uses an Extended Flowmeter Communication Protocol compatible with our

previous version ultrasonic flow meter, except for the commands in Italic in the following table.

Command	Meaning	Data format
DQD(cr) note 0	Returns flow rate per day	±d.dddddE±dd(cr) note 1
DQH(cr)	Returns flow rate per hour	±d.dddddE±dd(cr)
DQM(cr)	Returns flow rate per minute	±d.dddddE±dd(cr)
DQS(cr)	Returns flow rate per second	±d.dddddE±dd(cr)
DV(cr)	Returns fluid velocity	±d.dddddE±dd(cr)
DI+(cr)	Returns positive totalizer	±ddddddE±d(cr)note 2
DI-(cr)	Returns negative totalizer	±ddddddE±d(cr)
DIN(cr)	Returns net totalizer	±ddddddE±d(cr)
DIE(cr)	Returns net energy totalizer	±ddddddE±d(cr)
DIE+(cr)	Returns positive energy totalizer	±ddddddE±d(cr)
DIE-(cr)	Returns negative energy totalizer	±ddddddE±d(cr)
DIT(cr)	*Returns net total flow for today*	*±ddddddE±d(cr)*
DIM(cr)	*Returns net total flow for this month*	*±ddddddE±d(cr)*
DIY(cr)	*Returns net total flow for this year*	*±ddddddE±d(cr)*
DID(cr)	Returns the ID number/address	ddddd(cr) 5 bytes long
E(cr)	Return energy flow rate per hour	±d.dddddE±dd(cr)
DL(cr)	Returns the signal strength	UP:dd.d,DN:dd.d,Q=dd(cr)
DS(cr)	Returns percentage of AO output	±d.dddddE±dd(cr)
DC(cr)	Returns current error code	Note 3
DA(cr)	OCT and RELAY output	TR:s,RL:s(cr)note 4
DT(cr)	Returns the current date and time	yy-mm-dd,hh:mm:ss(cr)
Time@TDS1=(cr)	*Set date and time yy-mm-dd,hh:mm:ss*	
M@(cr)	Mimic key input. @ presents a key	M@(cr)note 5
LCD(cr)	Returns current window display	
LOCK0(cr)	*Unlock the system*	*Has nothing to do with the original password.*
LOCK1(cr)	*Lock the system*	*Can be opened by pressing the ENT key*
MENUXX(cr)	*Go to window XX*	
C1(cr)	OCT turns on	
C0(cr)	OCT turns off	
R1(cr)	RELAY(OCT2) turns on	
R0(cr)	RELAY(OCT2) turns off	
FOdddd(cr)	Output n Hz at frequency output	Fdddd(cr)(lf)
AOa(cr)	Output a mA current at AO output	AOa(cr)(lf)Note 6
BA1(cr)	Return the resistance for T1	±d.dddddE±dd(cr)(lf)

BA2(cr)	Return the resistance for T2	±d.dddddd±dd(cr)(lf)
BA3(cr)	Returns the current (0~20mA) at AI3	±d.dddddd±dd(cr)(lf)
BA4(cr)	Returns the current (0~20mA) at AI4	±d.dddddd±dd(cr)(lf)
BA5(cr)	Returns the current (0~20mA) at AI5	±d.dddddd±dd(cr)(lf)
AI1(cr)	Returns the temperature at T1 input	±d.dddddd±dd(cr)(lf)
AI2(cr)	Returns the temperature at T2 input	±d.dddddd±dd(cr)(lf)
AI3(cr)	Returns the value for AI3	±d.dddddd±dd(cr)(lf)
AI4(cr)	Returns the value for AI4	±d.dddddd±dd(cr)(lf)
AI5(cr)	Returns the value for AI5	±d.dddddd±dd(cr)(lf)
ESN(cr)	Returns the ESN number	ddddddd(cr)(lf) note 7
N	Prefix for single byte addressing network	Note 8
W	Prefix for ID string addressing network	Note 8
P	Prefix to returns with check-sum	
&	Command connector to make a super command in one line.	Result commands should not exceed 253 bytes long.
RING(cr)(lf)	Command for modem handshake	ATA(CR)(lf)
OK(cr)	Output by a modem	
	Output by flow meter to handshake a modem	AT(CR)(LF)
GA(cr)	Special command for GSM network.	note 9
GB(cr)	Special command for GSM network.	note 9
GC(cr)	Special command for GSM network	note 9

Notes:

0．(cr) is carriage return. Its ASCII value is 0DH. (lf) is line feed, and its ASCII value is 0AH.

1．'d' stands for digit 0~9. A value of 0 is presented by +0.000000E+00

2．'d' stands for digit 0~9. There is no dot before 'E'.

3．1~6 characters present the current state of the flow meter. See the meaning of the characters in the chapter Diagnostics.

4．'s' presents one of ON, OFF or UD

For example 'TR:ON,RL:ON' stands for that the OCT and RELAY are in ON state.

'TR:UD,RL:UD' stands for that the OCT and RELAY are not assigned.

5．@ is the key value. For example, 30H stands for the '0' key. The command 'M4(cr)' acts just like the number 4 key on the keypad.

6． 'a' stands for the output current. The maximum value should not exceed 20. For example AO2.34567, AO0.2

7． 'ddddddd' stands for the Electronic Serial Number

8． If there are more than one flow meter or other kinds of meters in a network, a prefix like 'N' or 'W' must be added before the basic command in the above table, otherwise the system might be confused.

9. The returns by the special command for GSM networks contain Chinese characters.

§6.4.1 Command prefixes and the command connector

（1） The P prefix

The P prefix can be added before every basic command to make the returned message with a check-sum. The check-sum is obtained by a binary addition. For example, if the command DI+(CR) (44H,49H,2BH,0DH in binary numbers brings a return like +1234567E+0m3 (CR) (2BH, 31H, 32H, 33H, 34H, 35H, 36H, 37H, 45H, 2BH, 30H, 6DH, 33H, 20H, 0DH, 0AH in binary numbers), then the PDI+(CR) will bring a return like +1234567E+0m3 !F7(CR). After the exclamation point '!' are the check-sum in ASCII format (2BH+31H+32H+33H+34H+35H+ 36H+37H+45H+2BH+30H+6DH+33H+20H=(2)F7H)

Please note that there may be no characters or only spaces before the exclamation point'!'.

（2） the N prefix

The use of prefix N goes like: N + single byte address + basic command.
For example, if the address number 88 flow meter is going to be addressed, the command should be: NXDV(CR), the decimal value of X being 88.

The prefix W is strongly recommended for new users.

（3） The W prefix

Usage: W + character string address + basic command

The value of the character string should have a value in the range of 0~65535, except for the value of 13（0DH carriage return）, 10（0AH line feed ）, 42（2AH * ）, 38（26H& ）.

For example, if the velocity of number 12345 flow meter is wanted, the command can be like: W12345DV(CR), (57H, 31H, 32H, 33H, 34H, 35H, 44H, 56H, 0DH in binary numbers)

（4） The command connecter &

The command connecter '&' adds several basic commands into a one-line super command. The super command should not exceed 253 characters. The prefix P should be added before every basic command for the returned results to have a check-sum.

For example, if the 1) flow rate 2) velocity 3) positive totalizer 4) net energy totalizer 5) the AI1 input 6) the AI2 input of the address number 4321 flow meter are required to return with check-sum, the one-line command should be:

W4321PDQD&PDV&PDI+&PDIE&PBA1&PAI2(CR)

The returned data are:

+0.000000E+00m3/d!AC(CR)
+0.000000E+00m/s!88(CR)
+1234567E+0m3 !F7(CR)
+0.000000E+0GJ!DA(CR)
+7.838879E+00mA!59
+3.911033E+01!8E(CR)

§6.4.2 Key Value Table

The key values are used in a network application. By use of the key value and a command 'M', we can operate the flow meter through the network on a computer or other kinds of terminals. For example, the command 'M0 (cr)' acts just like the Zero key on the keypad.

key	Key value (hexadecimal)	Key value (decimal)	ASCII value	key	Key value (hexadecimal)	Key value (decimal)	ASCII value
0	30H	48	0	8	38H	56	8
1	31H	49	1	9	39H	57	9
2	32H	50	2	.	3AH	58	:
3	33H	51	3	◄	3BH	59	;
4	34H	52	4	MENU	3CH	60	<
5	35H	53	5	ENT	3DH	61	=
6	36H	54	6	▲/+	3EH	62	>
7	37H	55	7	▼/-	3FH	63	?

§6.4.3 Programming Examples

Example 1: VB requests the instantaneous (in second) flow rate.

VB Code: mscom1.input = "dqs" + vbcrlf;

Example 2: VB requests the 4321 flowmeter to return the following data with checksum: (a) instantaneous flow rate; (b) instantaneous flow velocity; (c) Positive totalizer value; (d) Heat totalizer value; (e) AI1 input current; (f) AI2 input current.

VB Code: mscom1.input = "W4321PDQD&PDV&PDI+&PDIE&PBA1&PAI2" + vbcrlf;

Example 3: VB requests to change the pipe OD to 345mm.

VB Code: mscom1.input = "M<" +VBCRLF +"M1" +VBCRLF +"M1" +VBCRLF+"M3" +VBCRLF +"M4" +VBCRLF +"M5" +VBCRLF +"M=" +VBCRLF

Note that “M<” represents the MENU key, “M=” represents the ENT key, “M1” represents the “1” key.

8. Warranty and Service

§8.1 Warranty

The products manufactured by Spire Metering are warranted to be free from defects in materials and workmanship for a period of one year from the date of shipment to the original purchaser. Spire Metering's obligation should be limited to restoring the meter to normal operation or replacing the meter, at Spire Metering's choice, and shall be conditioned upon receiving written notice of any alleged defect within 10 days after its discovery. Spire Metering will determine if the return of the meter is necessary. If it is, the user should be responsible for the one-way shipping fee from the customer to the manufacturer.

Spire Metering is not liable to any defects or damage attributable to misusage, improper installation, out-of-spec operating conditions, replacement of unauthorized parts and acts of nature. Besides, fuses and batteries are not part of this warranty.

THE FOREGOING WARANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER EXPRESS OR IMPLIED WARRANTIES (INCLUDING BUT NOT LIMITED TO WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, AND WARRANTIES ARISING FROM DEALING, TRADE OR USAGE.)

§8.2 Service

The manufacturer provides instrument installation for its customers, and the charge will depend on the complexity of the installation.

For operational problems, please contact the technical support department by telephone, fax, email or internet. In most cases, problems could be solved immediately.

For any hardware failure of the instrument, we recommend our customers to send back the instrument for service. Please contact the technical support department with the model number and serial number of the unit before sending the unit back to us. Both numbers can be found on the product label. For each service or calibration request, we will issue a Return Materials Authorization (RMA) number.

Take notice that the cost for repairing can only be determined after receipt and inspection of the instrument. A quotation will be sent to the customer before proceeding with the service.

Important Notice for Product Return

Before returning the instrument for warranty repair or service, please read the following carefully:

1. If the return item has been exposed to nuclear or other radioactive environment, or has been in contact with hazardous material which could pose any danger to our personnel, the unit cannot be serviced.

2. If the return item has been exposed to or in contact with dangerous materials, but has been certified as hazard-free device by a recognized organization, you are required to supply the certification for the service.

3. If the return item does not have a RMA# associated, it will be sent back without any service conducted.

§8.3 Software Upgrade Service

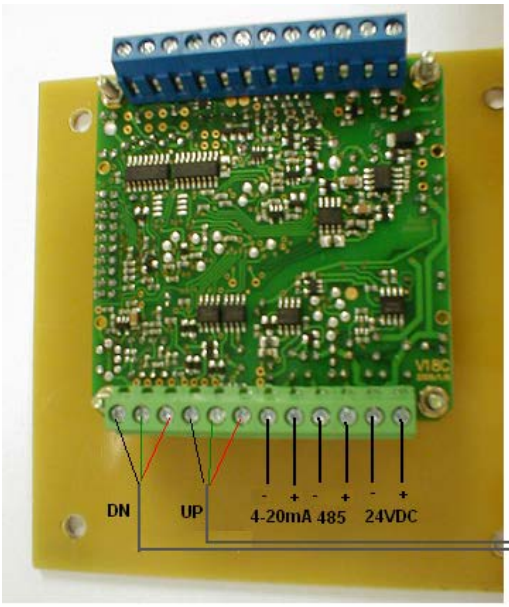
We provide free-of-charge software upgrade services. Please contact the manufacturer for the software upgrade information. You may also go to our technical support website at http://spiremt.com/products/enduroflow_series?id=2~~http://www.shenitech.com/support/stuf300.htm~~ for the latest download.

9. Appendix

§9.1 Wiring Diagram and Outline Drawings

WARNING!
Disconnect power before wiring. Otherwise, the on-board electronics may be damaged by misconnecting or static discharge!

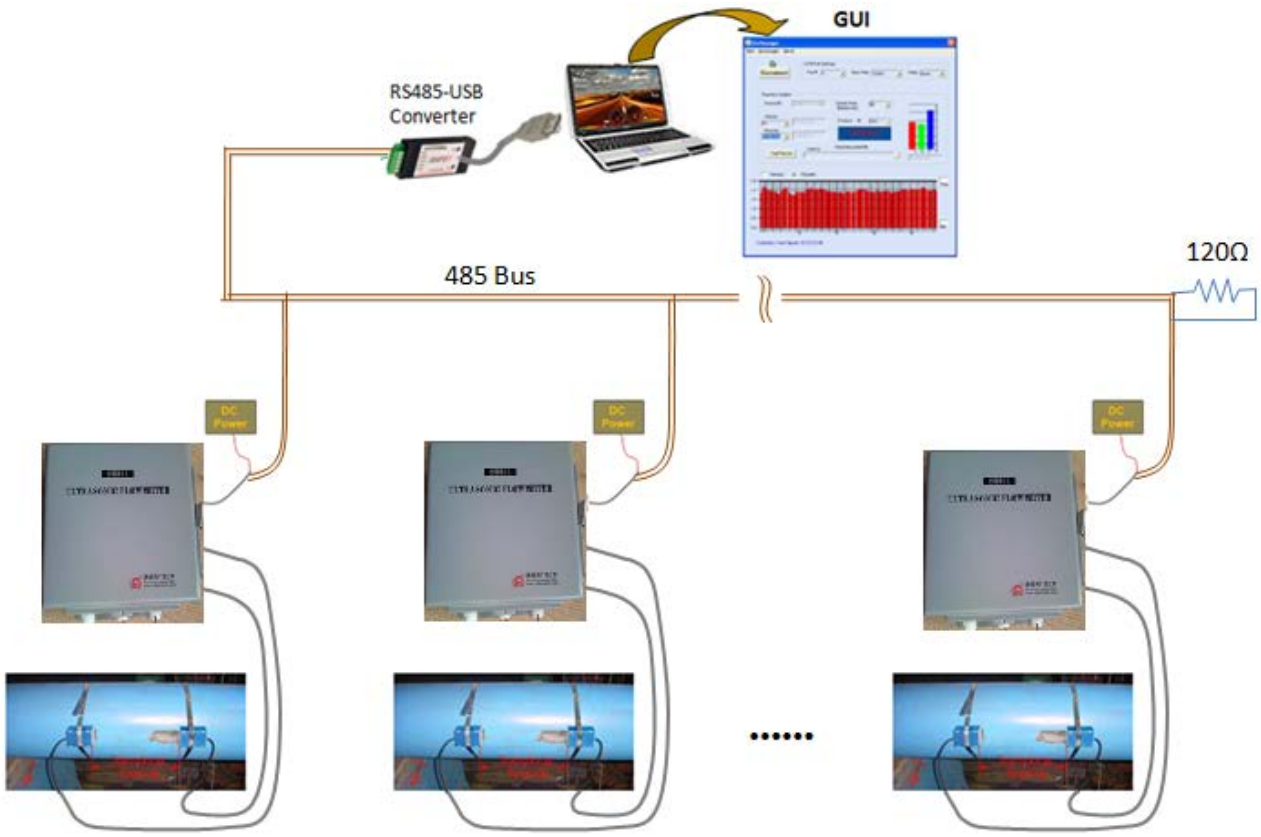
Open the panel



Open the main unit cover. Wire the power supply and the transducers according the above wiring diagram. After wiring is done, put the panel back.

Turn on the power (24VDC). The meter will be on immediately. It goes through a self-checking process to make sure everything is working properly. After a few seconds, main unit will enter into normal working status.

A typical flow measurement system is illustrated in the following figure.

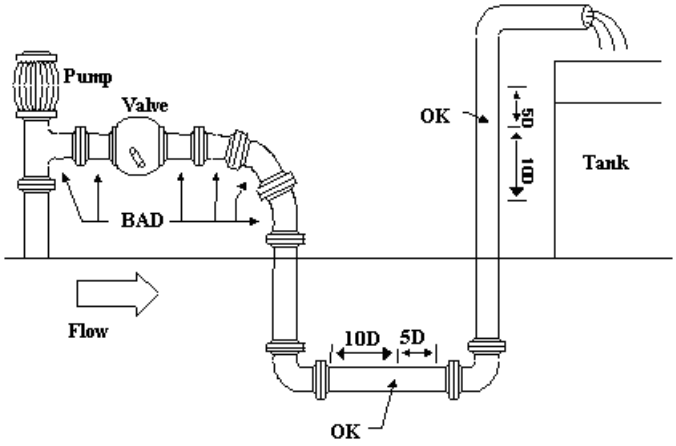


All the flowmeters are connected to a 485 bus which is then connected to data center computer. Each flowmeter has its own network address, so that the computer can query each flowmeter separately. The 120Ω terminator is needed when the 485 cable is long.

§9.2 Clamp-on Transducer Installation Guide

§9.2.1 Find the mounting site

(A) Pipe must be full of liquids at the measurement site.
(B) No heavy corrosion of deposition inside of the pipe.
(C) Must be a safe location.
(D) The straight run of the pipe must not be shorter than 15D as a general guideline, where D is the pipe diameter. Insufficient straight pipe length will degrade the accuracy of the results.
(E) The transducer mounting site should be 10D straight run upstream and 5D straight run downstream (see the following drawing.)
(F) If there are flow disturbing parts such as pumps, valves, etc. on the upstream, the straight pipe length should be increased. The disturbance strength of those flow conducting parts will be (low to high):
Single Bend -> Pipe Reduction / Enlargement -> Outflow Tee -> Same Plane Multiple Bends -> Inflow Tee -> Out of Plane Multiple Bends -> Valve -> Pump



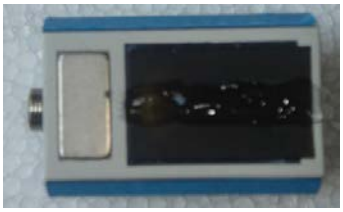
§9.2.2 Configure the Main Unit

Enter the pipe, fluid and transducer information in menus M11-M24. The flowmeter will calculate the transducer installation spacing for you and display the result in M25. This spacing will be used later.
Please note that, if your pipe material is PVC or other plastics, DO NOT select "5. PVC" in M14. Instead, select "9. Others". Then, enter the shear-wave sound speed of that material in M15. Normally, this sound speed is around 1060m/s (3478ft/s).

§9.2.3 Prepare the Pipe Surface

Clean the pipe surface where the transducers will be mounted. Remove rust and paint. Sand the surface if not smooth. Use wet cloth to wipe off the powder after sanding. Dry up the surface. A dry, clean surface will ensure a good acoustic bond between transducer and pipe.

§9.2.4 Prepare the Transducer

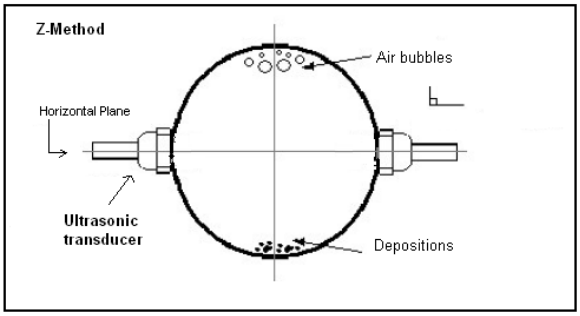


Clean the transducer surface. Keep the surface dry.
Put couplant on transducer surface as shown in the right figure. Do not put couplant more than necessary, especially for small pipe.

Note: Ultrasonic couplant can be grease, gel, and Vaseline, silicon or epoxy. Please read the instructions on those products carefully before using them. Spire Metering will not be responsible for any consequences caused by these products.

§9.2.5 Install the Transducers

Notice*:* For horizontal pipe line, it is recommended to install the transducers on the side instead of on the top or bottom of the pipe. This is to avoid air bubbles on the top and sediments on the bottom of the pipe.



First, mark the transducer installation location on the pipe surface according to the mounting spacing given in menu M25. You may need to make a paper template to help you accurately and quickly locate the transducer positions as well as to center the transducers, especially if you plan to use Z-method for the installation.

Then, connect the mounting fixture around the pipe. Leave the chain loose so you can slip the transducer underneath.

Apply a small amount of couplant in the prepared area of the pipe where transducers will be in contact.

Slip the transducer under the clamp fixture. Tighten

the screw. Do the same thing for the other transducer. Use the figure on the right as a reference.

If the pipe material is metal, you do not need the clamp fixture. The transducers will automatically attach to the pipe by magnetic force.

Finally, connect the transducer cables to the main unit.

§9.2.6 Fine Tune the Installation

Check the readings of the triplet (signal strength S, signal quality Q and transit-time ratio R) in menu window M90 and then M91. Make sure they are at least in the operational ranges:

***Operational Ranges*:** **$S \geq 60, \quad Q \geq 60, \quad 97\% \leq R \leq 103\%.$**

***Optimal Ranges*:** **$S \geq 80, \quad Q \geq 80, \quad 99\% \leq R \leq 101\%^{*}.$**

* *Note that when flow velocity is very high, the range for R may extend.*

In ideal case where pipe condition and fluid condition are favorable for sound propagation, the triplet readings could be fine turned into the optimal ranges. If your triplet readings are not close to their optimal ranges, or, even not in their operational ranges, you need to adjust your transducer installation slightly and slowly, until you get the best readings.

If you are unable to get the triplet into their operational ranges, no mater how hard you try, then, you may need to check all the parameters you entered in menu windows M11 to M24. Make sure those values are correct. Whenever you make a change to those parameters, you need to check the transducer spacing reading in menu M25. If the spacing is changed, you need to reinstall the transducers accordingly.

If you still cannot get the right triplet readings, check the following:

Is the pipe too old?
Too much deposition inside of the pipe?
Too much corrosion? Too much air bubble?
Too thick liner? Empty or half-full pipe?
Too close to pump / valve / elbow?

Please refer to section §2.11 for more suggestions. Please also check on our technical support website for more
tips, http://www.spiremt.com/enduroflow-series/ef12-solar-powerd-flowmeter.html

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§9.3 Insertion Transducer Installation Guide

A separate installation instruction should have been shipped with the product. If not, please contact the manufacturer at support@spiremt.com.

§9.4 Flow-cell Transducer Installation Guide

A separate installation instruction should have been shipped with the product. If not, please contact the manufacturer at support@spiremt.com.

§9.5 Standard Pipe Dimensions

Please refer to the following website for standard pipe dimensions: http://www.spiremt.com/support

§9.6 Sound Speed Tables

Table 9.6.1: Sound Speed in Water at atmosphere pressure. Unit：t (℃) v (m/s)

t	v	t	v	t	v	t	v
0	1402.3	25	1496.6	50	1542.5	75	1555.1
1	1407.3	26	1499.2	51	1543.5	76	1555.0
2	1412.2	27	1501.8	52	1544.6	77	1554.9
3	1416.9	28	1504.3	53	1545.5	78	1554.8
4	1421.6	29	1506.7	54	1546.4	79	1554.6
5	1426.1	30	1509.0	55	1547.3	80	1554.4
6	1430.5	31	1511.3	56	1548.1	81	1554.2
7	1434.8	32	1513.5	57	1548.9	82	1553.9
8	1439.1	33	1515.7	58	1549.6	83	1553.6
9	1443.2	34	1517.7	59	1550.3	84	1553.2
10	1447.2	35	1519.7	60	1550.9	85	1552.8
11	1451.1	36	1521.7	61	1551.5	86	1552.4
12	1454.9	37	1523.5	62	1552.0	87	1552.0
13	1458.7	38	1525.3	63	1552.5	88	1551.5
14	1462.3	39	1527.1	64	1553.0	89	1551.0
15	1465.8	40	1528.8	65	1553.4	90	1550.4
16	1469.3	41	1530.4	66	1553.7	91	1549.8
17	1472.7	42	1532.0	67	1554.0	92	1549.2
18	1476.0	43	1533.5	68	1554.3	93	1548.5
19	1479.1	44	1534.9	69	1554.5	94	1547.5
20	1482.3	45	1536.3	70	1554.7	95	1547.1
21	1485.3	46	1537.7	71	1554.9	96	1546.3
22	1488.2	47	1538.9	72	1555.0	97	1545.6
23	1491.1	48	1540.2	73	1555.0	98	1544.7
24	1493.9	49	1541.3	74	1555.1	99	1543.9

Table 9.6.2: Sound Speed and Viscosity Data of Liquids

Liquids	Sound Speed @ 25 ℃(77 ℉)		Kinematic Viscosity X 10^{-6}	
	m/s	ft/s	m^2/s	ft^2/s
Acetone	1,174	3,851.7	0.399	4.293
Acetaldehyde Alcohol	1,180	3,870		
Alcohol	1,207	3,960	1.396	15.02
Aviation kerosene	1,298	4,257		
Benzene	1,306	4,284.8	0.711	7.65
Carbine	1,121	3,677		
Ethanol	1,207	3,690	1.39	14.956
Ethyl benzene	1,586	4,389.8 (68°F)	0.797 (17 ℃)	8.575 (63°F)
Ethylene chloride	1,193	3,914	0.61	6.563
Ethylene trichloride	1,050	3,444		
Gasoline	1,250	4,100	0.8	0.1980
Gasoline 66#	1,171	3,841		
Gasoline 80#	1,139	3,736		
Glycol	1658	5,439.6		
50%Glycol / 50%H2O	1,578	5,177		
Glycerin	1,904	6,246.7	757.1	8,081.8
Ketone	1,310	4,297		
Kerosene	1,420	4,658	2.3	24.7
Oil (Castor)	1,477	4,854.8	0.670	7.209
Oil (Diesel)	1,250	4,101		
Oil (Peanut)	1,458	4,783.5		
Petroleum	1,290	4,231		
Tetrachlor-Methane	926	3,038.1	0.607	6.531
Toluene	1,328 (20 ℃)	4,357 (68°F)	0.644	6.929
Water, distilled	1,498	4,914.7	1.0	10.76

Table 9.6.3: Sound Speed Data of Solids

Material	Sound Speed Shear Wave（25 ℃）		Sound Speed Long. Wave（25 ℃）	
	m/s	ft/s	mm/us	in/us
Steel, 1% Carbon, hardened	3,150	10,335	5.88	0.2315
Carbon Steel	3,230	10,598	5.89	0.2319
Mild Steel	3,235	10,614	5.89	0.2319
Steel,1% Carbon	3,220	10,565		
302 Stainless Steel	3,120	10,236	5.690	0.224
303 Stainless Steel	3,120	10,236	5.640	0.222
304 Stainless Steel	3,141	10,306	5.920	0.233
304L Stainless Steel	3,070	10,073	5.790	0.228
316 Stainless Steel	3,272	10,735	5.720	0.225
347 Stainless Steel	3,095	10,512	5.720	0.225
Aluminum	3,100	10,171	6.32	0.2488
Aluminum（rolled）	3,040	9,974		
Copper	2,260	7,415	4.66	0.1835
Copper（annealed）	2,235	7,628		
Copper（rolled）	2,270	7,448		
CuNi（70%Cu 30%Ni）	2,540	8,334	5.03	0.1980
CuNi（90%Cu 10%Ni）	2,060	6,759	4.01	0.1579
Brass（Naval）	2,120	6,923	4.43	0.1744
Gold（hard-drawn）	1,200	3,937	3.24	0.1276
Inconel	3,020	9,909	5.82	0.2291
Iron（electrolytic）	3,240	10,630	5.90	0.2323
Iron（Armco）	3,240	10,630	5.90	0.2323
Ductile Iron	3,000	9,843		
Cast Iron	2,500	8,203	4.55	0.1791
Monel	2,720	8,924	5.35	0.2106

Table 9.6.3 (continued): Sound Speeds in Solids

Material	Sound Speed Shear Wave（25 ℃）		Sound Speed Long Wave（25 ℃）	
	m/s	ft/s	mm/us	in/us
Nickel	2,960	9,712	5.63	0.2217
Tin,rolled	1,670	5,479	3.32	0.1307
Tintanium	3,125	10,253	6.10	0.2402
Tungsten,annealed	2,890	9,482	5.18	0.2039
Tungsten,drawn	2,640	8,661		
Tungsten,carbide	3,980	13,058		
Zinc,rolled	2,440	8,005	4.17	0.1642
Glass,Pyrex	3,280	10,761	5.61	0.2209
Glass,heavy silicate flint	2,380	7,808		
Glass,Iight borate crown	2,840	9,318	5.26	0.2071
Nylon	1,150	3,772	2.40	0.0945
Nylon,6-6	1,070	3,510		
Polyethylene（LD）			2.31	0.0909
Polyethylene（LD）	540	1,772	1.94	0.0764
PVC,CPVC	1,060	3,477	2.40	0.0945
Acrylic	1,430	4,690	2.73	0.1075
Asbestos Cement			2.20	0.0866
Tar Epoxy			2.00	0.0787
Mortar			2.50	0.0984
Rubber			1.90	0.00748