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Application Note

Flexim F601 Ultrasonic Flow Meter



Figure 1 Flexim F601 parts

1) Control console
2) Ultrasonic transducers
3) Magnetic transducer mounting rails
4) RTD temperature probes (PT100)

Not shown:

5) Power supply
6) Pipe diameter tape measure
7) Chain extensions
8) Pipe wall thickness gauge

Overview

The Flexim F601 Ultrasonic Liquid Flow Meter measures liquid and energy flow in a pipe. It has clamp-on sensors for non-intrusive installation and measurement, without requiring probes be physically inserted into the pipe. The F601 has data logging capabilities and a digital display for instantaneous flow measurements.

In mechanical systems, ultrasonic liquid flow meters are most commonly used for HVAC chilled and hot water applications but are also useful in industrial processes. All applications require that no gas-phase substance is present.

Applications

The F601 Flow Meter is often used for:

- liquid and/or thermal energy flow
- Water demand analysis, including leaks. The portable flow meter can serve as a sub-meter to measure cumulative amount of water used by a device or a sub-system of a larger metered system.
- Diagnosing system performance issues like variation in flow and flow direction

Thermal Flow Monitoring

The F601 kit includes two precision RTD temperature probes whose outputs are integrated with flow measurements at the meter. Thus it is well suited for energy flow measurements. Thermal flow is calculated in the meter using the flow rate and the associated supply and return fluid temperatures.

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Theory of transit-time flow measurement

Flow Transducers

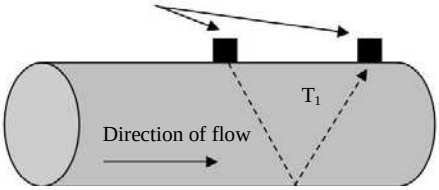


Figure 2a The ultrasonic **signal** takes time **T1** to travel downstream between transducers

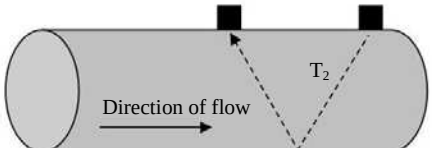


Figure 2b The ultrasonic signal takes time **T2** to travel upstream between transducers

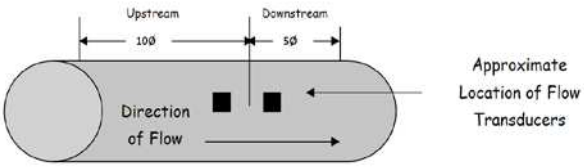


Figure 3a Locate sensors following the 2/3 – 1/3 rule with a minimum distance of 15x pipe diameters between flow obstructions (pipe fittings, probes, etc.)

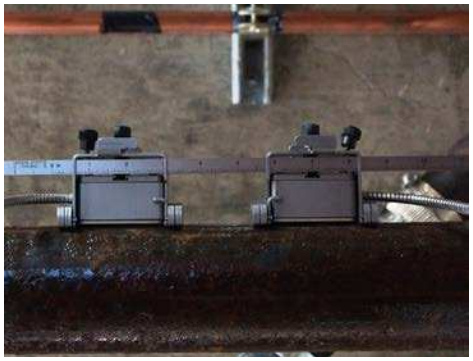
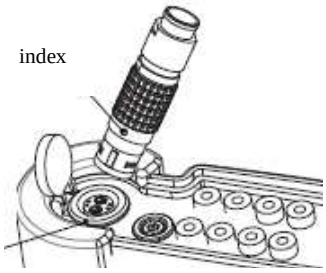


Figure3b Pipe mounting using magnetic attachments



Channel "A"

Figure 4 Insert transducer cable end into meter channel "A". Observe index key and conductor pins during insertion.

How it Works (Figures 2a&b)

The flow meter uses a pair of ultrasonic wave transducers, with each transducer sending and receiving coded ultrasonic signals through the fluid. In **Transit time mode**, when the fluid is flowing, signal transit time in the downstream direction (Figure 2a) is shorter than in the upstream direction (Figure 2b). The flow meter measures this time difference (ΔT), which is proportional to the flow velocity. It then calculates velocity based on ΔT and other conditions provided by the user including liquid temperature, pipe characteristics, and fluid characteristics. See **Fluxus F601 User Manual** (**FUM**) chapter 3 page 15 for more information on theory of operation.

If particulates or entrained bubbles prevent good transit time measurements, the meter can be configured to use Flexim's Doppler technology (called **NoiseTrek** mode) instead of transit time. See **FUM "3.2.2 Determination of the Volumetric Flow Rate in the NoiseTrek Mode"** on pages 17 – 18 for theory of operation.

HybridTrek is the same as NoiseTrek, but it automatically switches between Transit time and Doppler. It is set in the **SYSTEM settings\Measuring** branch of the menu system. See **FUM "13.3 Settings of the HybridTrek Mode"** on p.83-4 for details.

Operation

All citations refer to **Fluxus F601 User Manual** (**FUM**) unless otherwise noted.

Installation and Setup

1. If you plan to integrate the Flexim flow data with data from other sources taken at the same time, you should synchronize all data to a common clock. See Appendix C, Downloading data, for more information before proceeding further.

2. Select pipe monitoring point for transducer mounting (**FUM** ch5 p23). See figure 3a.

3. Prepare the pipe surface at the monitoring point (**FUM** ch8.1 p51).

4. Connect the flow transducer cable to the meter (**FUM** ch6.3 p30). See figure 4.

5. Mount the flow transducer set on the pipe at the selected monitoring point without couplant. See figure 3b. Observe the correct positioning of the transducers by noting the embossed flow direction arrow (**FUM** chs 8.2 and 8.3, p51-4).

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Figure 5 Turn meter on and off (UM10.1 p61).

MENU Navigation:

- #8 and #2 keys to scroll up and down
- #4 and #6 keys to scroll left or right
- Press ENTER to make a selection
- Clear Key ("C") to clear/delete an entered value
- Break key ("BRK") to interrupt measurement OR Jump to Main Menu at any time during setup or operation

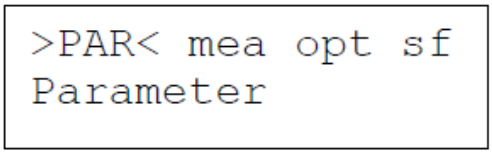


Figure 6 Meter's Main Menu display with PAR selected.

6. Review keypad operation before proceeding (**FUM** ch 4.4 p21). See figure 5.

7. Turn meter on (**FUM** ch 10.1 p61). See figure 5. The meter will briefly display a message saying "CLAMPON DETECTED ON A:" (or B if channel B is used for transducer input), followed by a brief meter ID message. Then the main menu appears in the meter's digital display with one of 4 options selected: **par** (parameters)**, mea** (measuring)**, opt** (output options)**,** or **sf** (special functions). See figure 6.

8. Using the keypad → and ← keys, move the cursor to the **SF** branch and press [ENTER]. Press the ↑ or ↓ keys to select System Settings [ENTER], then select Set Clock [ENTER]. Select OK to accept or NEW to update the displayed time. Press [ENTER] to accept changes. Repeat this process for the Date value. Then press the [BRK] key to return to the top menu.

Refer to the laminated **Quick Start** (**QS**) **Guide** card to continue with setup steps 8, 9, and 10 below. Begin with the **Parameter Input** menu branch, then turn the card over and continue with **Output Options** and **Measuring** branches.

9. Move cursor to the **PAR** branch (**FUM** ch 11.1 pp 65-70) and enter parameter values indicated in the **QS Guide** at the prompts. As you proceed, note the following:

   - Measure outside pipe diameter with the pipe diameter tape measure provided with the meter.
   - If the pipe material is known, use the pipe materials data sheet to look up wall thickness based on the pipe diameter for that material. If pipe material is unknown, use the thickness gage to measure the pipe wall thickness (see **Appendix B** in this document).
   - For pipe roughness value, use the meter's default value, or see **FUM** Appendix C-2, p234 (.0005" - .002" for carbon steel).
   - After all values are entered, press the **BRK** key to return to the main menu.

10. Follow QS guide for **OPT** values (**FUM** ch 12.1 p76). Data logging is activated in this branch if desired (**FUM** ch 14 p93). If temperature logging is desired, turn T1 and T2 on when prompted, and refer to Appendix A for more information.

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11. Follow **QS guide** for **MEA** values (**FUM** ch 11.4 p70). This is the branch where measurements (and logging if selected) are initiated. If logging, provide a value (e. g, "1") for Measuring Points when prompted (**FUM** ch 11.5 p71). Select "2" or "4" for the sound paths (number of traverses) value (**FUM** ch 11.5 p71). If a negative value is displayed, increase the number of traverses to the next even number (e.g., from "2" to "4").

12. If logging, go to SF/System settings/storing for additional settings (ringbuffer, storage mode and other logging parameters)

13. Transducer spacing should first be set to the value recommended by the meter. If the signal is below 1 bar with no coupling paste, Adjust the flow transducer spacing to maximize signal strength (number of bars on the console display) and achieve a constant green LED status indicator (**FUM** ch 11.6 p72 and QS guide). For adjusting transducer spacing for optimum accuracy see **Consistency Check** (**FUM** ch 11.6.2 p73-4).

14. When proper spacing is achieved, remove the transducers to apply the coupling paste then re-install the transducers. Using fingers only, tighten them snugly against the pipe but NOT "gorilla tight". DO NOT USE TOOLS TO TIGHTEN. Only 3-5 bars of signal strength are needed for a reliable signal. Trying for more than 5 bars has no effect on accuracy and has no other benefit.

15. If recording a running total flow is desired, set Totalizers with the "8" key after measurements have begun (**FUM** ch 13.2 p80). Press "8" 1 time to set totalizers, or 3 times to reset them. Press "2" 3 times to turn off totalizer.

16. Data measurement (flow, velocity, etc.) is in progress when the active channel's LED is green. In its default configuration the meter also beeps each time data is logged to signify that logging is in progress. The meter must be left in this condition for logging to continue. Do not hit the BRK key, which will halt logging and measurement display.

17. Press the "3" and "9" keys to cycle through selected measurement and diagnostic values such as volume, flow, totalizers, temperature, sound speed, log file fill date, measurement status values (S, Q, c, RT, F), and battery level.

18. Note the F601 batteries will support up to 11 hours of logging, depending on logging interval and battery condition. For longer logging periods, use the power supply provided reliable operation for the duration of the logging period.

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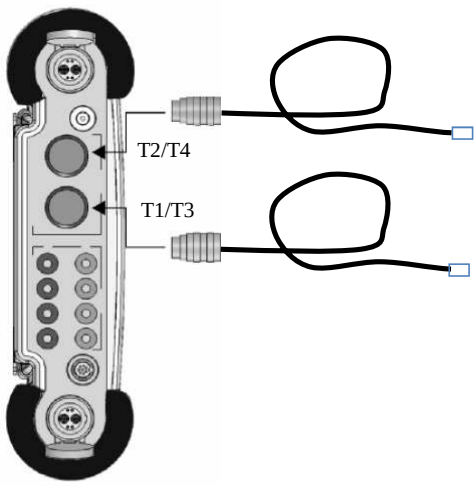


Figure 7a (Optional) Insert RTD sensor cable ends into meter T1 and T2 inputs. These are threaded connections.



Figure 7b (Optional) Properly mounted RTD sensor with insulating pad and chain clamp

Appendix A: temperature monitoring with 100Ω RTD probes

Refer to **FUM** ch20 p138 for more information on thermal flow measurement setup.

Connect the RTD temperature transducers to the meter (FUM ch 6.3 p30). See figures 7a and 7b.

Mount the probes at properly selected prepared temperature monitoring points (FUM ch 9.3 and 9.4, p57-58). Use temperature conductive paste ("heat sink compound") if available for the most accurate temperature data.

As noted in Operation step 11, temperature logging is activated by turning T1 and T2 on in the OPT branch (FUM ch 14 p93). Using the ↑ or ↓ and [ENTER] keys, select the desired channel (typically "A")

From the special functions (SF) menu, use the arrow keys to navigate to Special Funct.\SYSTEM settings\Proc. Inputs. Using the ↑ or ↓ and [ENTER] keys, select Link Temperature then configure the following parameters:

- Link temperature = heat or chill
- thermal energy = heat or chill
- transducer location = return or supply
- thermal energy = absolute or sign
- T-Supply = Input T1
- T-Return = Input T2
- T(3) and T(4) = no measuring

Return to the Proc. inputs menu option above. Using arrow and ENTER keys, select PT100 / PT1000 and configure the following parameters:

- Input T1 = pt100
- Input T2 = pt100

Select T-Supply = T1 and T-Return = T2 (be sure the RTD placement is reflected in your selections).

Select Proc inputs \ PT100 / PT1000 = Input T1 PT100
Select Proc inputs \ PT100 / PT1000 = Input T2 PT100

Select values for thermal energy (heat/chill), Transducer location (return/supply), and Thermal energy (absolute/sign)

For more information on temperature Inputs see **FUP** ch21 p148-153.

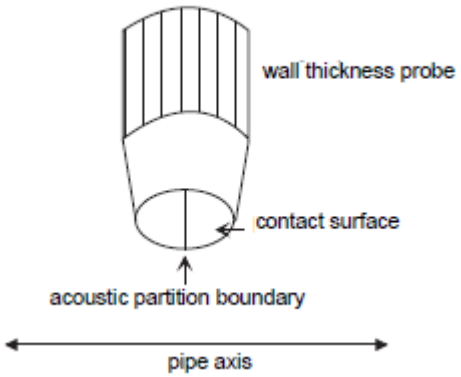
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Pipe thickness gage



Close-up of probe's acoustic partition boundary



Boundary should be perpendicular to pipe axis when measuring thickness

Appendix B: Using the Thickness Gage

If the pipe wall thickness is unknown and cannot be determined by look up charts, use the ultrasonic thickness gage provided to measure its thickness. More information on the thickness gauge can be found in the **F601 User Manual** (**FUM** ch 19 p133).

1. Plug the gage in the console's B channel and watch for the message identifying the device.
2. Push **BRK** key to go to top menu if necessary
3. Go to **PAR** menu [ENTER]
4. Select Channel B [ENTER]
5. Select Pipe material [ENTER]
6. Write down C-long value if desired [ENTER]
7. Hit **BRK,** then go to **MEA** menu [ENTER]
8. At "wall T-inch?" prompt, make measurement (e.g., .211 for steel pipe)
9. Confirm measurement and record for later use [ENTER]. You may wish to compare the measurement with values found in the pipe size data sheet for comparable pipe material.
10. At "Transfer Data?" select **yes** [ENTER], but note that the value transfers only to current B channel and must be re-entered in the A channel PAR values (see below).
11. Remove thickness gage probe from channel B (to avoid damage, do NOT pull on the cable, and pull only on the LEMO style connector!)
12. Hit **BRK,** then go to **PAR** menu [ENTER]
13. Select **channel A** [ENTER]
14. Find wall thickness parm and enter value recorded in step 9 above [ENTER]
15. Hit **BRK,** then go to **MEA** menu [ENTER] and begin measurements.

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Appendix C: Downloading data

Please note:

The Tool Lending Library has seen instability in the Fluxdata application. It fails to load in some environments. On a few occasions during data download, we have seen severe errors trigger a sudden computer abnormal termination ("blue screen"). In these instances, **any unsaved data in other open applications may be lost**. Fortunately, the collected data in the flow meter remains intact and can be re-downloaded once the computer is re-started and normal operation is restored.

We recommend saving files and closing applications before downloading Flexim data as a precaution to safeguard any work-in-progress in other applications. We have notified Flexim about our concerns with their software and will continue to work with them on resolution.

Synchronize F601 to PC clock (optional):

If you plan to integrate the Flexim flow data with data from other sources taken at the same time, you should synchronize all data to a common clock. This must be done BEFORE logging is started for any data source you intend to synchronize. Follow the first 3 steps below. Then, in the FluxData application, select menu option DUT / Date & Time, and click "Select Actual Time", then OK. The meter and PC clocks now agree, and data fro any other loggers also synchronized to the same PC will be easily integrated using spreadsheet or database software.

1. Connect meter to PC with RS232 cable into COM port or a USB RS232 serial port adapter (e.g., Keyspan). Note the COM port assigned to the connection.
2. Start FluxData..exe
3. Set the proper COM port in the application (options/serial interface, select COM port in dropdown listbox. Click Save (BTW, "Abbrechen" is German for "Cancel"), then OK (**FUP** 14.2.7 p101-2)
4. The Protocol button displays the connection parameters and will match the meter's default values (9600 baud/8 bits/even parity/2 stop bits). Leave them and blocksize at their default values (**FUP** p99 sect 14.2.4). These values must agree with the PC's Device Manager COM port settings.
5. We suggest stopping logging before proceeding with the download.
6. Click File/Receive to download data (or the leftmost icon in the toolbar)
7. Downloading data during data logging interrupts but does not stop logging. Logging resumes after download is complete (1 or more minutes).
8. By default, totalizers do not reset between logging sessions. Set Special Funct.\SYSTEM settings\Measuring\Quantity recall=OFF to reset totalizers on any interruption.

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Other interesting and helpful information

- See **HotCodes** handout for more information on HotCodes p63 sect 10.3
- For **imperial/SI** units selection go to sf\system settings\dialogs menus\
- For more **imperial/SI** units selection use HotCode 007020
- If setting **display contrast** and display goes blank, reset with HotCode 555000 (system settings\miscellaneous\contrast)
- For **programming tree** see p62 sect 10.2.2
- For **BTU Mode** p143 sect 20.3
- If **medium temperature** varies more than +/- 20 degrees, consider RTD input p69 sect 10.3
- To review **remaining memory** (for log files), see p97 sect 14.1.6 (sf\special functions\instrument inform.\free=112493)

If signal strength is good at zero flow but diminishes when flow is present, it may be a sign of entrained air bubbles preventing a good signal. Consider configuring the meter for direct (one traverse) measurement.

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