Flow Rate Sensor
BT40i
User's Guide

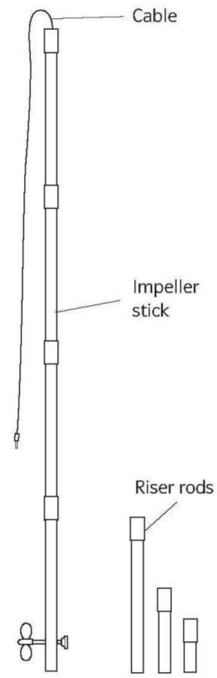
CENTRE FOR MICROCOMPUTER APPLICATIONS

https://cma-science.nl

Short description

The Flow rate sensor BT40i measures the velocity of flowing water. It can be used to study the discharge, flow patterns, and sediment transport of flowing water.
The Flow rate sensor is equipped with impeller stick, which consists of:

- An impeller and coupled sensor in which a switch opens and closes as the impeller is rotated by the flow of water.
- Four long tube sections, which slot together to make a 1.1 m stick.
- Three "riser rods" which when slotted singly or in combination, allow the impeller to be elevated above the streambed at fixed heights. The total length of the impeller rod, including all 3 risers, is circa 1.6 m.
- A 1-m long cable, which connects to the Flow sensor box.



When the Flow rate sensor is placed in a stream, water flows against the blades of the impeller, causing it to turn. The faster the water flows, the faster the impeller turns. A bar magnet rotating with the impeller triggers a reed switch. The switch sends pulses, which are converted into a voltage signal that is proportional to flow rate.
The Flow sensor can be directly connected to analog BT inputs of CMA interfaces. The sensor cable BT - IEEE1394 needed to connect the sensor to an interface is not supplied with the sensor and has to be purchased separately (Order Code BTsc_1).

Left: the sensor impeller
Right: the sensor bar magnet with reed switch.

Sensor recognition

The Flow Rate sensor BT40i has a memory chip (EEPROM) with information about the sensor: its name, measured quantity, unit and calibration. Through a simple protocol this information is read by the CMA interfaces and the sensor is automatically recognized when it is connected to these interfaces. If your Flow Rate sensor is not automatically detected by an interface you have to manually set up your sensor by selecting it from the Coach Sensor Library.

Calibration

The CMA Flow Rate sensor BT40i is supplied calibrated. The output of the sensor is linear with respect to the measured flow rate:

$$\text{Flow (m/s)} = 1 * V_{out} \text{ (V)}$$

The Coach software allows selecting the calibration supplied by the sensor memory (EEPROM) or the calibration stored in the Coach Sensor Library. For better accuracy the pre-defined calibration can be shifted.

Operating instructions

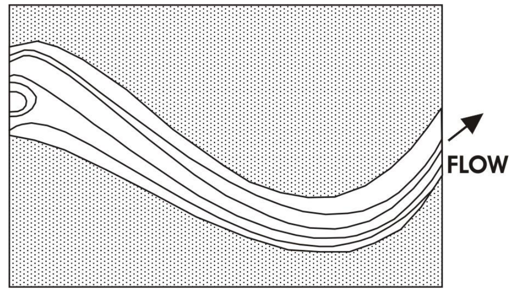
To assemble the sensor, slot the rods of the impeller stick unit together and connect the jack plug to the sensor box. Point the impeller up into the flow of moving water at the required depth. Use one or more of the three “riser” rods to elevate the impeller off the stream bed if necessary.

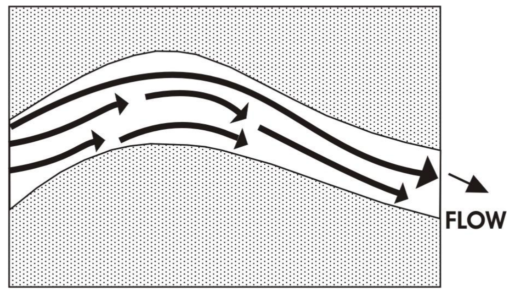
Examples of experiments

The Flow rate sensor can be used in the following experiments:

- ***Calculating Discharge***
  Stream flow or discharge is the volume of water that moves through a specific point in a stream during a given period of time. To determine discharge, a cross-sectional area of the stream or river is measured. Then, the velocity of the stream is measured using a Flow rate sensor. The discharge can then be calculated by multiplying the cross-sectional area by the flow velocity.
- ***Determining sediment transport rate for a stream or other body of water***
  The amount of sediment and maximum particle size that can be transported by moving water is related to the flow velocity. Therefore, flow velocity data obtained using the Flow rate sensor can be used to determine what size particles will stay in motion at a particular flow velocity. For a given flow velocity there is a range of behavioral possibilities for sediment particles lying on the bed, or entrained within the flow of a stream. For example, at a measured flow velocity of 1 m/s, silt and sand (though not compacted clay) will be eroded from the stream bed and transported downstream. At the same velocity, all sediment particles between 10 mm and 100 mm that were already in motion will continue in motion. Particles greater than 100 mm will be deposited. Thus, a Flow rate sensor can be a valuable observational tool when used in sediment transportation studies.

- ***Measuring and comparing flow rate at various locations in a stream***
  Using the Flow rate sensor, it is possible to map flow characteristics of a stream by taking measurements at different spots and depths. To understand the flow characteristics within streams of moving water, it is helpful to construct Stream Lines and Vector Lines. The first illustration shows how Stream Lines depict possible paths of a single fluid particle. Vector Lines represent both the flow rate and direction. The longer and broader the line, the greater the flow velocity. Vector Lines convey useful information about the stream flow characteristics. In this diagram the short thin arrows represent the slower areas of the stream and the long, thick lines the regions of faster flow.





Procedure for Measuring Stream Flow

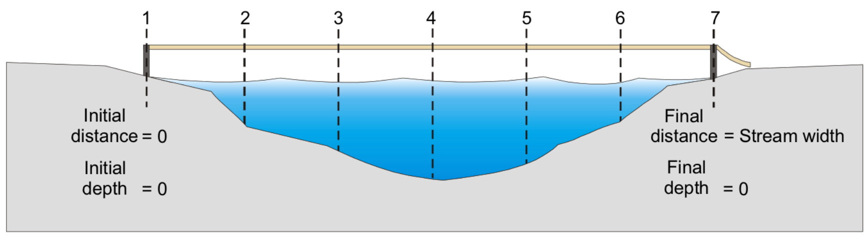
1. Site Selection

- Always follow safety precautions when entering the stream. If the water is too deep or swift, select another site. Never venture out into the stream alone without another person available to assist you in case of emergency.
- Select two sites within a 50 m stretch of the stream that are as far apart as possible and are representative of the stream as a whole. Avoid sites with bends or breaks in the stream caused by rocks or sandbars. Try to choose a site where some flow can be observed. One site can have a swift flow similar to that found in a riffle. The second site can have a moderate or slow flow like that found after a pool. It is not necessary for both sites to be the same.
- At each site, you are going to take a cross section of the stream and measure its width and depth. Try to select a cross section that is shallow enough to measure depth with a meter stick and easy to cross. To measure stream flow using the Flow rate sensor, avoid sites where the stream depth is less than 10 cm.

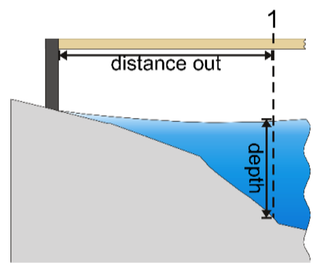
2. Measuring a Stream Cross-Section

This is essential for meaningful stream velocity recording. A plan or "map" of the stream cross- section at each point where measurements are to be made forms the basis for recording observations.

- Using measuring tape, determine the width of the stream cross-section in meters and record the measurement on a data sheet. Divide the cross-section into equally spaced sections.

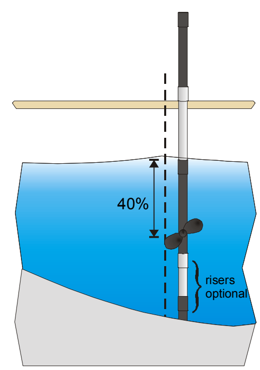


- Using a meter stick, measure the depth of the stream in meters at each of the equally spaced points along the cross section. Record the depth and the distance out from one shore edge, in meters, on a data sheet. Always measure from the same shore. Be sure to include both the initial distance and depth and the final distance and depth.

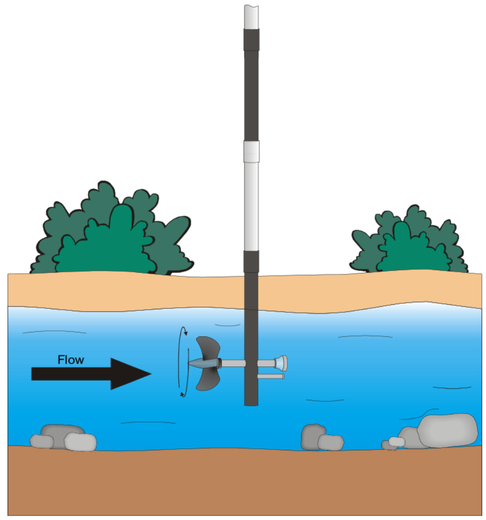


3. Measuring Flow Velocity

- Connect the Flow rate sensor to your data-logger.
- Submerge the impeller of the Flow rate sensor to about 40% of the depth measured at each section. If the section is shallow enough, use the plastic risers that are included with the Flow rate sensor to support the sensor on the stream bed. The risers make it easier to keep the impeller of the sensor in the same spot and oriented in the same direction.



- Point the impeller of the sensor upstream (as shown below) and place it into the flow. Hold the sensor in place for 10 seconds while data are being collected. Repeat the measurement for each of the remaining sections.



4. Calculating Stream Cross-section

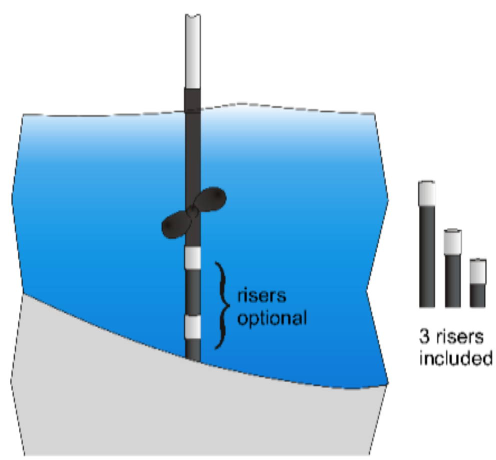
- Create a graph of stream depth *vs*. distance from the shore.
- Integrate the data. The integral value will give you the cross-sectional area of the stream.

5. Determining Discharge

- Calculate the average velocity for each site.
- To calculate the discharge or stream flow, multiply the average stream velocity by the cross-sectional area. Repeat for Site 2.

Additional tips

1. The plastic risers that come with the Flow rate sensor can be very helpful in keeping the sensor at the same orientation while taking measurements.
   When using the risers, simply place the bottom of the sensor rod against the stream bottom. If you are unsure which riser to use, start with the medium riser first and gauge the depth from there.
2. When students are selecting sites to take flow measurements, they should choose a site where the stream is not split by rocks, partially submerged obstructions, or sand bars.



3. The impeller of the Flow rate sensor should always be pointing into the flow when measurements are being made. Students need to stand on the shore when taking measurements close to the shore, or stand as far downstream as possible from the sensor when placing the sensor in deeper water.
4. Because stream flow is easily affected by weather conditions, it is important that good notes concerning date, time, and weather be taken whenever flow measurements are made.

Storage and Maintenance of the Flow rate sensor

When you have finished using the Flow rate sensor, simply rinse it with clean water and dry it using a paper towel or cloth. The probe can then be folded up and stored.
To prolong the life of your Flow rate sensor, we recommend that the moving parts of the impeller rod be lubricated, after every few field uses.
When using the impeller rod, avoid hitting the impeller blade on rocks and other hard surfaces. If the impeller blade is bent, it will decrease the accuracy of the sensor.

Technical Specifications

Sensor kind	Analog, generates an output voltage between 0 – 5 V
Flow rate range	0 - 4.0 m/s
Calibration function	Flow (m/s) = 1.0 * V_{out} (V)
Resolution using 12 bit A/D converter	0.005 m/s
Accuracy	±1% of full-scale reading
Response time	98% of full-scale reading in 5 seconds, 100% of full-scale in 15 seconds
Temperature range	0 to 70°C
Connection	IEEE1394 connector for BT-IEEE1394 sensor cable. Sensor cable not delivered with the sensor.

Warranty:

The Flow Rate sensor BT40i is warranted to be free from defects in materials and workmanship for a period of 24 months from the date of purchase provided that it has been used under normal laboratory conditions. This warranty does not apply if the sensor has been damaged by accident or misuse.

Note: *This product is to be used for educational purposes only. It is not appropriate for industrial, medical, research, or commercial applications.*

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