

## FS1023-DL

Liquid Flow Sensor Module

The [FS1023-DL](#) liquid flow sensor module measures the flow rate using the thermo-transfer (calorimetric) principle.

The FS1023-DL offers key advantages over resistor-based flow solutions. The sensor uses thermopile sensing, which provides an excellent signal-to-noise ratio. The sensor comprises a “solid” thermal isolation technology with protective coating.

The non-linear flow output curve allows for sensitivity from low to full-scale flow rates. The FS1023-DL provides digital I<sup>2</sup>C and analog output.

### Module Picture



### Features

- Liquid flow: 0 to 3 liters/min (in water)
- Robust “solid” isolation technology
- Resistant to vibration and pressure shock
- Minimal flow resistance
- Digital I<sup>2</sup>C output
- Analog voltage output
- Supply voltage: 5V

### Applications

- Water dispensers
- Liquid metering or switch
- Process controls and monitoring

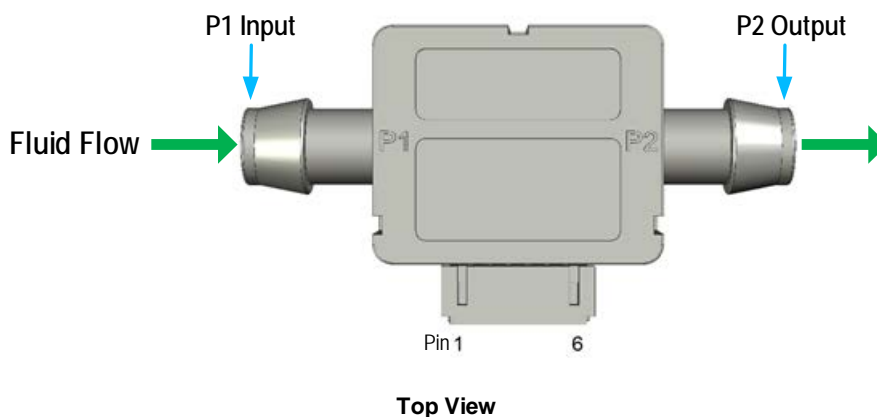


## Contents

|   |           |
|---|-----------|
| <b>1. Pin Information</b>                 | <b>3</b>  |
| 1.1 Pin Assignments                       | 3         |
| 1.2 Pin Descriptions                      | 3         |
| <b>2. Specifications</b>                  | <b>4</b>  |
| 2.1 Absolute Maximum Ratings              | 4         |
| 2.2 Recommended Operating Conditions      | 4         |
| 2.3 Electrical Characteristics            | 4         |
| <b>3. Typical Flow Graphs</b>             | <b>5</b>  |
| <b>4. I<sup>2</sup>C Sensor Interface</b> | <b>7</b>  |
| 4.1 Sensor Slave Address                  | 7         |
| 4.2 I <sup>2</sup> C Communication        | 7         |
| 4.3 Digital Output Measurements           | 8         |
| 4.4 Calculating Checksum                  | 8         |
| 4.5 Electrical Connector                  | 9         |
| 4.6 Module Material                       | 9         |
| 4.7 Tubing Guidance                       | 9         |
| <b>5. Package Outline Drawings</b>        | <b>10</b> |
| <b>6. Ordering Information</b>            | <b>10</b> |
| <b>7. Revision History</b>                | <b>10</b> |

# 1. Pin Information

## 1.1 Pin Assignments



## 1.2 Pin Descriptions

| Pin Number | Pin Name | Type         | Description                     |
|------------|----------|--------------|---------------------------------|
| 1          | VDD      | Input        | Supply voltage.                 |
| 2          | GND      | Input        | Ground.                         |
| 3          | OUTPUT   | Output       | Flow analog output.             |
| 4          | SDA      | Input/Output | Serial data.                    |
| 5          | SCL      | Input        | Serial clock.                   |
| 6          | NC       | -            | Do not connect <sup>[1]</sup> . |

1. "NC" stands for not connected / no connection required / not bonded.

## 2. Specifications

### 2.1 Absolute Maximum Ratings

**CAUTION:** Do not operate at or near the maximum ratings listed for extended periods of time. Exposure to such conditions can adversely impact product reliability and result in failures not covered by warranty.

| Symbol     | Parameter           | Conditions | Minimum | Maximum | Unit |
|------------|---------------------|------------|---------|---------|------|
| $V_{IN}$   | Supply Voltage      | -          | 2.7     | 5.5     | V    |
| $T_{STOR}$ | Storage Temperature | -          | 0       | 85      | °C   |

### 2.2 Recommended Operating Conditions

| Symbol     | Parameter                              | Minimum | Typical | Maximum | Unit |
|------------|--|---------|---------|---------|------|
| $V_{IN}$   | Supply Voltage                         | 4.7     | 5       | 5.5     | V    |
| $T_{AMB}$  | Ambient Operating Temperature (in air) | 0       | -       | 70      | °C   |
| $P_{STAT}$ | Static Pressure                        | -       | -       | 30      | PSI  |

### 2.3 Electrical Characteristics

| Symbol     | Parameter                         | Conditions                          | Minimum | Typical | Maximum | Unit      |
|------------|-----------------------------------|-------------------------------------|---------|---------|---------|-----------|
| $I_{VIN}$  | Current Consumption               | -                                   | -       | 20      | 25      | mA        |
| $F_{LQ}$   | Liquid Flow Range                 | Tested with water, room temperature | 0       | -       | 3       | Liter/min |
| $V_{AOUT}$ | Analog Voltage Output             | At 0 liters/min                     | -       | 0.5     | -       | V         |
|            |                                   | At 3 liters/min                     | -       | 4.5     | -       |           |
| $V_{DOUT}$ | Digital Output                    | At 0 liters/min                     | -       | 409     | -       | Counts    |
|            |                                   | At 3 liters/min                     | -       | 3660    | -       |           |
| $\tau_H$   | Flow Response Time <sup>[1]</sup> | -                                   | -       | 5       | -       | msec      |

- The flow response time includes a 10% to 90% rise time for the flow sensor to electrically respond to any flow change. Measurements may be affected by the pneumatic interface.

### 3. Typical Flow Graphs

Figure 1 and Figure 2 show the typical digital and analog output versus flow, with water, room temperature.

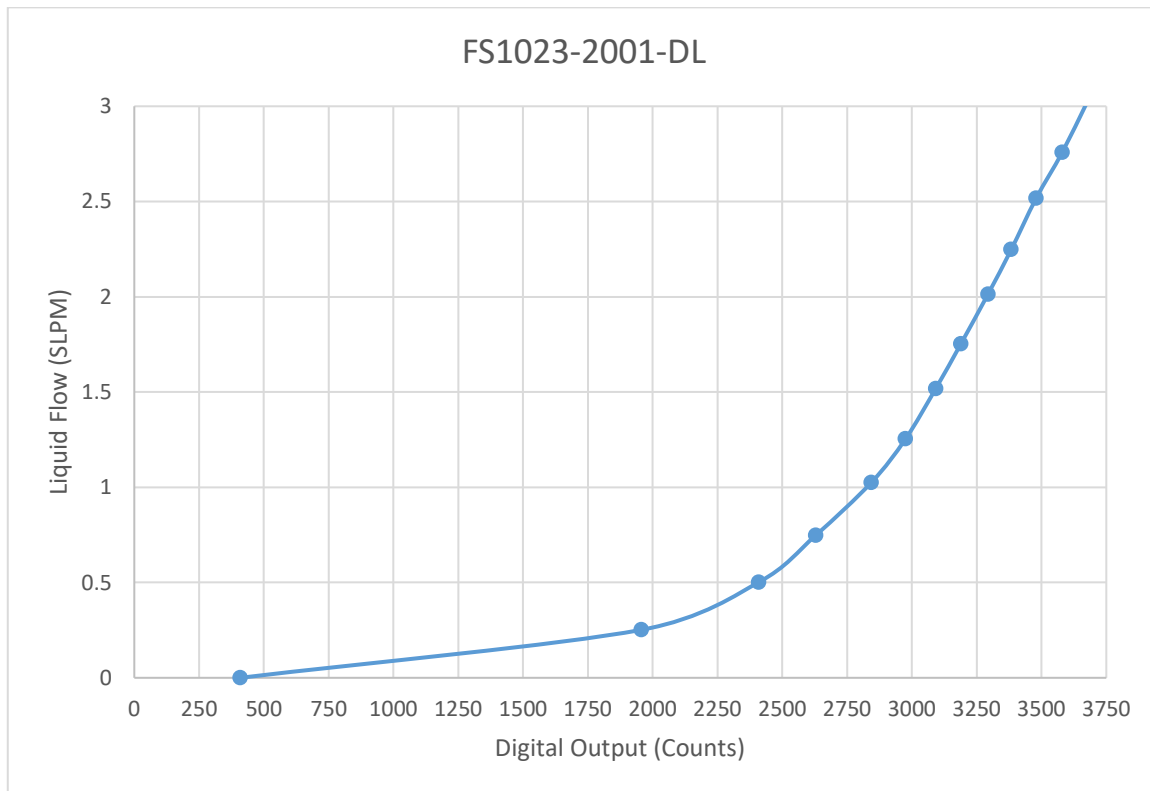


Figure 1. Digital Output Curve

| Flow (Liters/min) | Digital Output (Counts) |
|-------------------|-------------------------|
| 0                 | 409                     |
| 0.252             | 1957                    |
| 0.501             | 2408                    |
| 0.748             | 2629                    |
| 1.026             | 2844                    |
| 1.253             | 2975                    |
| 1.518             | 3092                    |
| 1.753             | 3189                    |
| 2.012             | 3293                    |
| 2.247             | 3383                    |
| 2.516             | 3479                    |
| 2.758             | 3580                    |
| 3.027             | 3678                    |

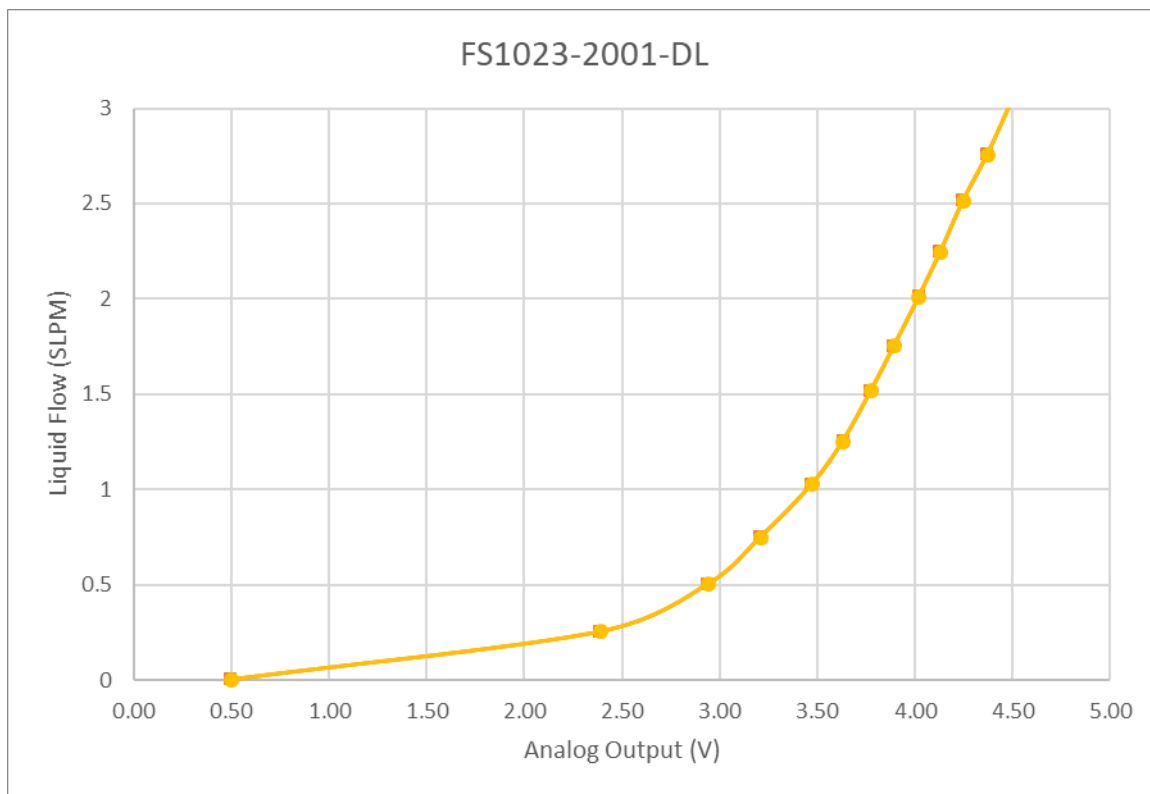


Figure 2. Analog Output Curve

| Flow (Liters/min) | Analog Output (V) |
|-------------------|-------------------|
| 0                 | 0.50              |
| 0.252             | 2.39              |
| 0.501             | 2.94              |
| 0.748             | 3.21              |
| 1.026             | 3.47              |
| 1.253             | 3.63              |
| 1.518             | 3.77              |
| 1.753             | 3.89              |
| 2.012             | 4.02              |
| 2.247             | 4.13              |
| 2.516             | 4.25              |
| 2.758             | 4.37              |
| 3.027             | 4.49              |

## 4. I<sup>2</sup>C Sensor Interface

The FS1023-DL includes a digital I<sup>2</sup>C two-wire interface with a bidirectional data line (SDA) and a clock line (SCL). The two lines are open-drain, and are connected to the supply voltage via two pull-up resistors (Rp). The FS1023-DL operates as a slave device on the I<sup>2</sup>C bus with support of 100kHz and 400kHz bit rates.

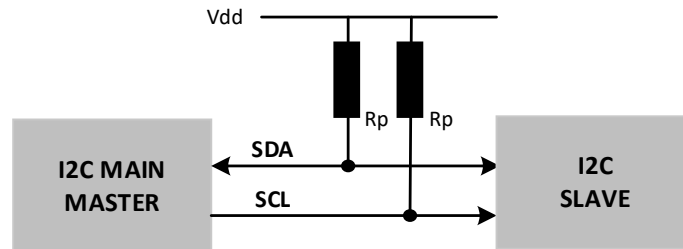


Figure 3. I<sup>2</sup>C Master-Slave Configuration

The recommended pull-up resistor (Rp) values depend on the system implementation; however, a value between 2.2kΩ and 10kΩ can be used.

The capacitive load on both SDA and SCL should be the same, therefore, the signal lengths should be similar to avoid asymmetry.

### 4.1 Sensor Slave Address

The FS1023-DL default I<sup>2</sup>C address is **50HEX**. The device will respond only to this **7-bit address**.

### 4.2 I<sup>2</sup>C Communication

The START condition is used to initiate I<sup>2</sup>C communication by the master. The sensor transmission is initiated when the master sends a 0 START bit (S). A HIGH to LOW transition on the SDA line while the SCL is HIGH indicates the beginning of a transmission.

The STOP condition is used to stop I<sup>2</sup>C communication by the master. The transmission is terminated when the master sends a 1 STOP bit (P). A LOW to HIGH transition on the SDA line while the SCL is HIGH indicates the end of a transmission.

All transfers consist of 8 bits and a response bit: 0 for Acknowledge (ACK) or 1 for Not Acknowledge (NACK). After the ACK is received, another data byte can be transferred or the communication can be stopped with a STOP bit.

The master expects an ACK back from the slave after each byte is transmitted. The slave pulls the SDA low to indicate that it has received a byte and then it frees the I<sup>2</sup>C bus again. If the slave does not initiate an ACK then it will consider it a NACK.

Data on the SDA line is always sampled on the rising edge of the SCL line and must remain stable while SCL is HIGH to prevent false START or STOP conditions.

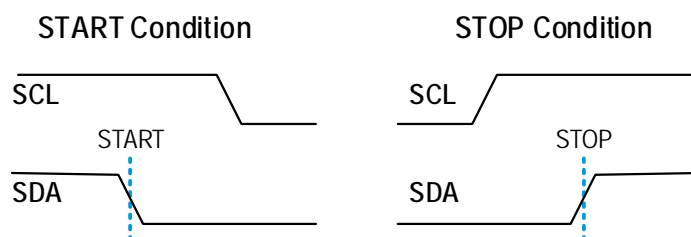


Figure 4. START and STOP Condition Waveform

### 4.3 Digital Output Measurements

The FS1023-DL continuously measures in operation.

The data is sent in byte packages. Each byte is followed by an ACK from the slave. The most significant bit (MSB) is transmitted first.

To read the data, the following command is sent to the FS1023-DL.

After the START bit, the master device sends the 7-bit slave address followed by an eighth bit = 1 (READ). The READ bit indicates a transmission from the FS1023-DL (slave) to master (see Figure 5).

The checksum used for data integrity is returned from the FS1023-DL followed by the two bytes of flow data.

The flow data is a 12-bit integer. Only the least significant four bits in the high byte are valid (see Figure 6).

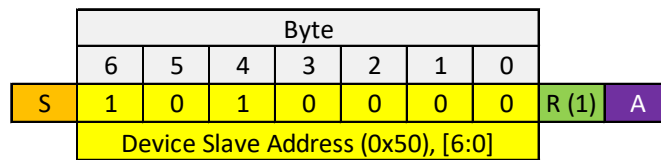
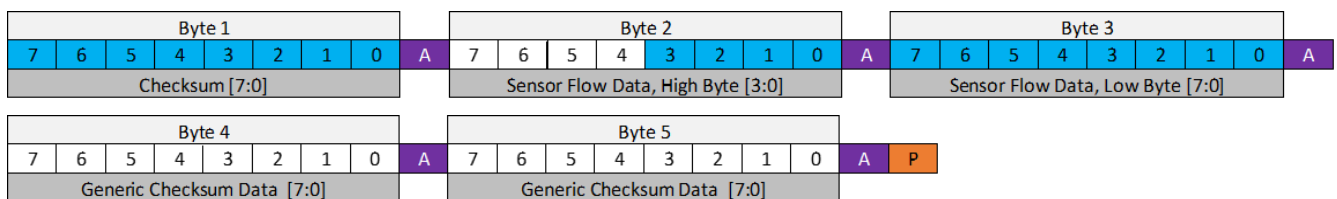


Figure 5. Flow Data Read Command



**S** START Condition

**R** READ Mode

**P** STOP Condition

**A** Acknowledge (ACK)

Figure 6. Flow Data from FS1023-DL

### 4.4 Calculating Checksum

The checksum used for data integrity is the 2's complement (negative) of the 256-modulo (8-bit) sum of the data bytes (does not include I<sup>2</sup>C address).

Figure 7 shows the 5 bytes read:

**Example:**

Byte 1, 0xCC (Checksum)

Byte 2, 0x01

Byte 3, 0x99

Byte 4, 0x01 or 0x00

Byte 5, 0x99 or 0x00



The 256-modulo (8-bit) sum is calculated as:

$$(EQ) 1 \quad sum = 0x01 + 0x99 + 0x01 + 0x99 = 0x134$$

Validating the data payload is done by calculating the sum and adding it to the checksum. If the result is 0x00, then the data is valid.

$$(EQ) 2 \quad checksum + sum = 0xCC + 0x134 = 0x00$$

## 4.5 Electrical Connector

A 6-position receptacle (not provided) is required to mate to the board crimp style connector. A part number example is PHR-6 (JST).

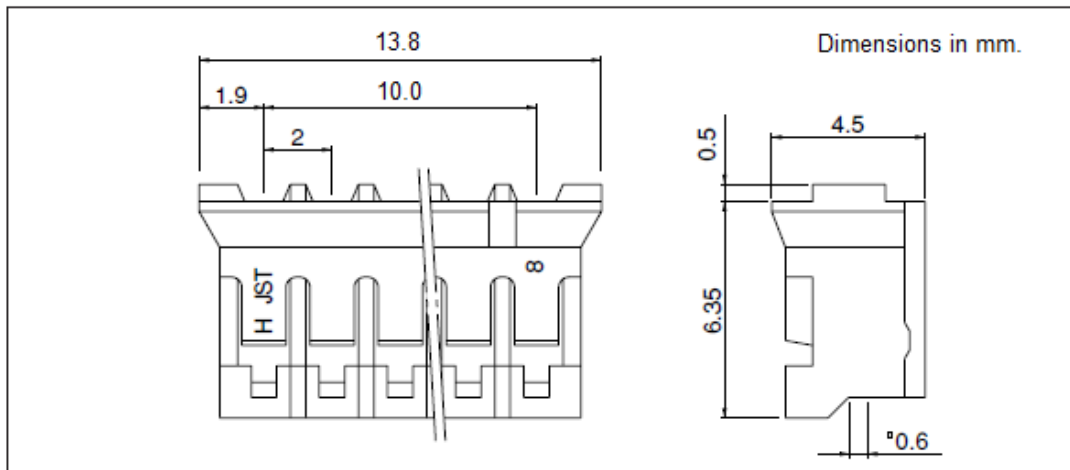


Figure 8. Receptacle Drawing

## 4.6 Module Material

The wetted contact surface of the FS1023-DL consists of the following:

- Housing – Polyphenylene Ether (PPE) + Polystyrene (PS) blend resin
- Parylene
- Gasket – Silicone

## 4.7 Tubing Guidance

The FS1023-DL module has barb tube endings. Soft tubing with a nominal 3/8-inch (9.5mm) internal diameter is recommended for use. A clamp may be necessary to secure the tubing over the barb.

## 5. Package Outline Drawings

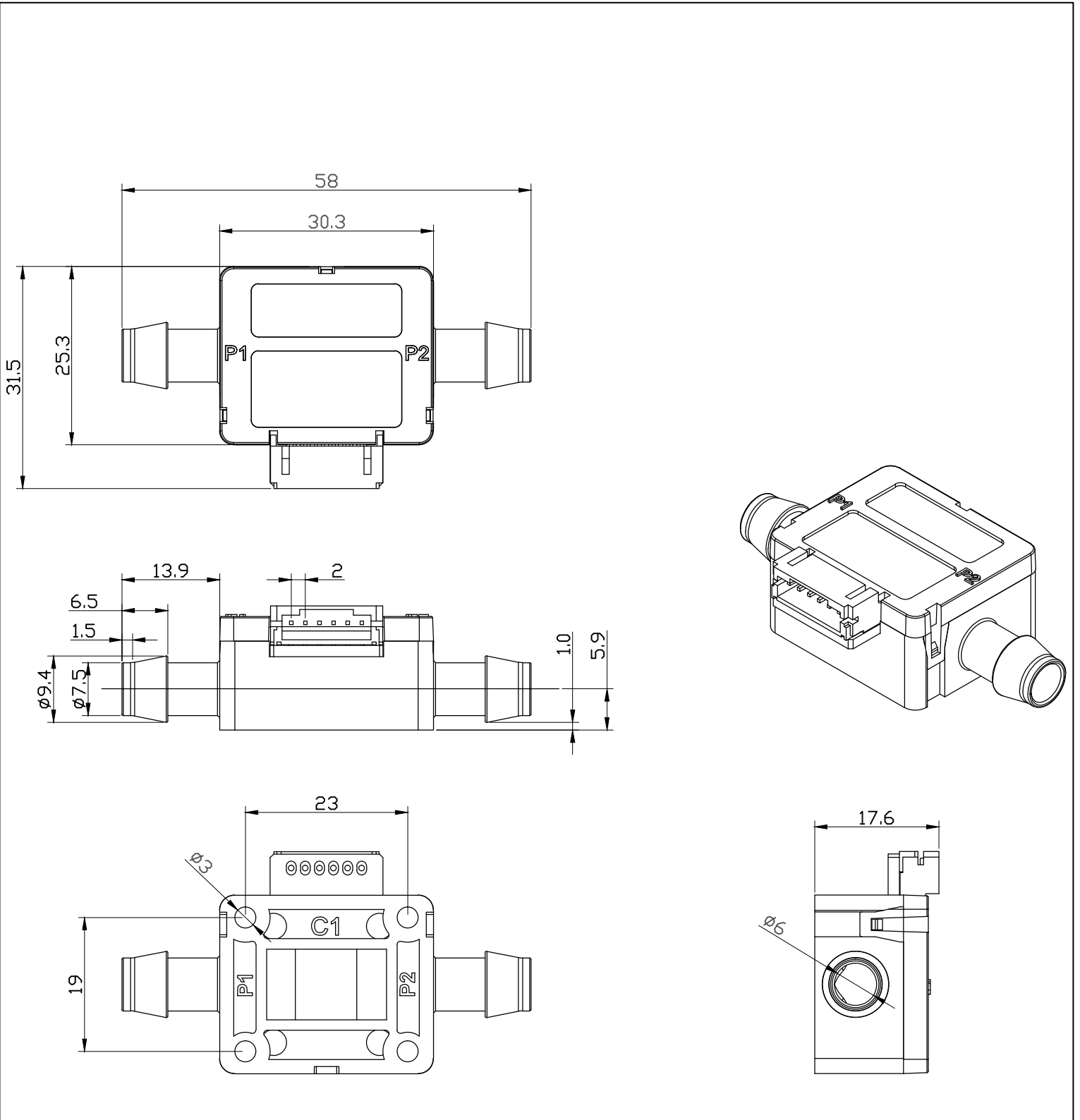
The package outline drawings are located at the end of this document and are accessible from the Renesas website (see Ordering Information for POD links). The package information is the most current data available and is subject to change without revision of this document.

## 6. Ordering Information

| Part Number    | Package Description   | Carrier Type | Temperature Range |
|----------------|---|--------------|-------------------|
| FS1023-2001-DL | 0 to 3 liter/min liquid flow sensor module with digital and analog voltage output (see <a href="#">MOD1</a> ) | Tray         | 0° to +70°C       |

## 7. Revision History

| Revision | Date        | Description                    |
|----------|-------------|--------------------------------|
| 1.02     | Sep 1, 2022 | Updated reference with water.  |
| 1.01     | Jul 1, 2021 | Corrected current consumption. |
| 1.00     | Mar 2, 2021 | Initial release.               |



| Package Revision History |         |                 |
|--------------------------|---------|-----------------|
| Date Created             | Rev No. | Description     |
| Nov 28, 2017             | Rev 00  | Initial Release |

## IMPORTANT NOTICE AND DISCLAIMER

RENESAS ELECTRONICS CORPORATION AND ITS SUBSIDIARIES (“RENESAS”) PROVIDES TECHNICAL SPECIFICATIONS AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS OR IMPLIED, INCLUDING, WITHOUT LIMITATION, ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for developers skilled in the art designing with Renesas products. You are solely responsible for (1) selecting the appropriate products for your application, (2) designing, validating, and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. Renesas grants you permission to use these resources only for development of an application that uses Renesas products. Other reproduction or use of these resources is strictly prohibited. No license is granted to any other Renesas intellectual property or to any third party intellectual property. Renesas disclaims responsibility for, and you will fully indemnify Renesas and its representatives against, any claims, damages, costs, losses, or liabilities arising out of your use of these resources. Renesas' products are provided only subject to Renesas' Terms and Conditions of Sale or other applicable terms agreed to in writing. No use of any Renesas resources expands or otherwise alters any applicable warranties or warranty disclaimers for these products.

(Rev.1.0 Mar 2020)

### Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,  
Koto-ku, Tokyo 135-0061, Japan  
[www.renesas.com](http://www.renesas.com)

### Contact Information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit:  
[www.renesas.com/contact/](http://www.renesas.com/contact/)

### Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.