

FS1025-DG

Gas Flow Sensor Module

The FS1025-DG Gas Flow Sensor Module measures the flow rate using the thermo-transfer (calorimetric) principle.

The FS1025-DG 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 FS1025-DG provides calibrated linear output through digital I²C and analog interface.

FS1025-DG Module Picture



Features

- Gas flow: 0 to 150 liters/min (in nitrogen or air)
- Robust “solid” isolation technology
- Resistant to vibration and pressure shock
- Minimal flow resistance
- Fast response: < 5ms
- Digital I²C output
- Analog voltage output
- Supply voltage: 5V

Applications

- Ventilators
- Gas metering equipment
- Process controls and monitoring

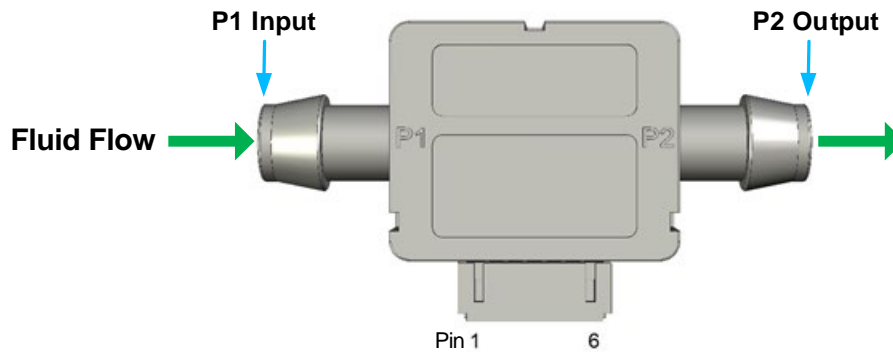


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1. Pin Information

1.1 Pin Assignments



FS1025-DG Module Pin Assignments – Top View

1.2 Pin Descriptions

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

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 | 105 | °C |
| V_{PIN} | Voltage on All Other Pins | - | -0.3 | $V_{CC} + 0.3$ | V |
| I_{PIN} | Input Current on Any Pin | - | -80 | 80 | mA |
| ESD_{HBM} | ESD Human Body Model | - | - | 2.5 | kV |
| ESD_{CDM} | ESD Charged Device Model | - | - | 750 | V |

2.2 Recommended Operating Conditions

| Symbol | Parameter | Minimum | Typical | Maximum | Unit |
|-----------|--|---------|---------|---------|------|
| V_{IN} | Supply Voltage | - | 5 | - | V |
| T_{AMB} | Ambient Operating Temperature (in air) | 0 | 20 | 85 | °C |
| P_{CM} | Common-Mode Pressure | - | - | 30 | PSI |

2.3 Electrical Specifications

| Symbol | Parameter | Conditions | Minimum | Typical | Maximum | Units |
|------------|-----------------------------------|--|---------|---------|---------|------------|
| I_{VIN} | Current Consumption | - | - | 21 | - | mA |
| F_{LQ} | Gas Flow Range | Tested with nitrogen or air, room temperature. | 0 | - | 150 | Liters/min |
| V_{AOUT} | Analog Output | At 0 liters/min. | - | 0.5 | - | V |
| | | At 150 liters/min. | - | 4.5 | - | |
| V_{DOUT} | Digital Output | At 0 liters/min. | - | 409 | - | Counts |
| | | At 150 liters/min. | - | 3686 | - | |
| E_{Flow} | Flow Accuracy ^[1] | - | - | 1.5 | 5 | % Reading |
| τ_H | Flow Response Time ^[2] | - | - | 5 | - | msec |

1. Calibration Standard Condition: 25°C, 1bar, nitrogen gas.
2. The flow response time includes a 10% to 90% rise time for the flow sensor to electrically respond to any gas flow change. Measurements might be affected by the pneumatic interface.

2.4 I2C Electrical Specifications

| Symbol | Parameter | Standard Mode | | Fast Mode | | Unit |
|---------------|----------------------------|---------------|-----|-----------|-------|---------|
| | | Min | Max | Min | Max | |
| f_{SCL} | SCL Clock Frequency | - | 100 | - | 400 | kHz |
| $t_{SCL(H)}$ | SCL Clock High Time | 4.5 | - | 1.125 | - | μ s |
| $t_{SCL(L)}$ | SCL Clock Low Time | 4.5 | - | 1.125 | - | μ s |
| t_{FALL} | SCL and SDA Fall Time | - | 1.3 | - | 0.34 | μ s |
| t_{RISE} | SCL and SDA Rise Time | - | 1.3 | - | 0.34 | μ s |
| $t_{SU(SDA)}$ | SDA Data Setup Time | 500 | - | 125 | - | ns |
| $t_{H(SDA)}$ | SDA Data Hold Time | 100 | - | 100 | - | ns |
| $t_{VD(SDA)}$ | SDA Data Valid Time | - | 1.6 | - | 0.475 | μ s |
| $t_{SU(STA)}$ | START Condition Setup Time | 500 | - | 125 | - | ns |
| $t_{H(STA)}$ | START Condition Hold Time | 100 | - | 100 | - | ns |
| $t_{SU(STO)}$ | STOP Condition Setup Time | 500 | - | 125 | - | ns |

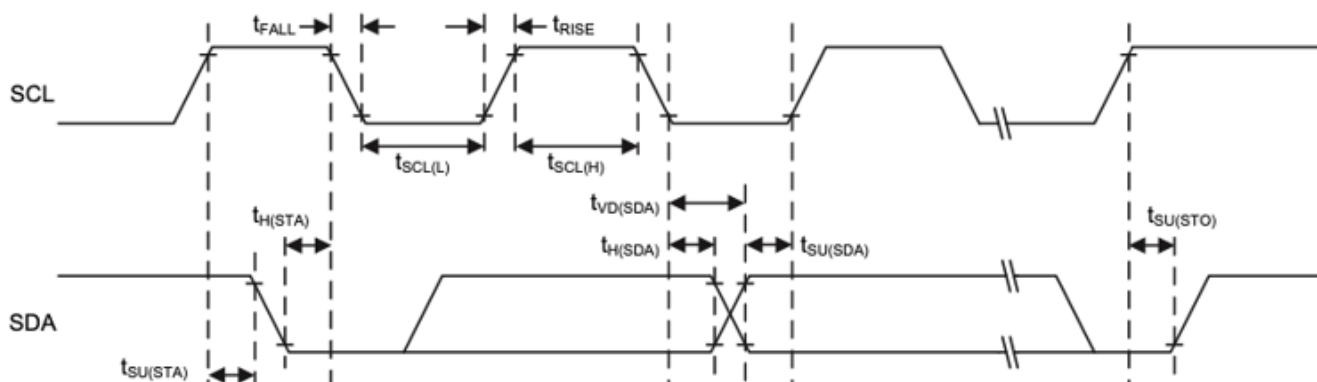
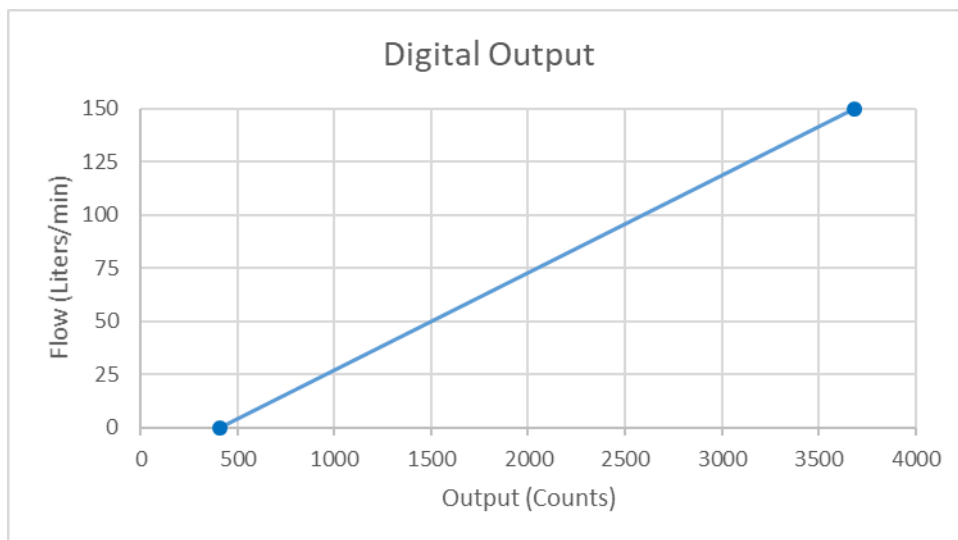


Figure 1. I2C Timing Diagram

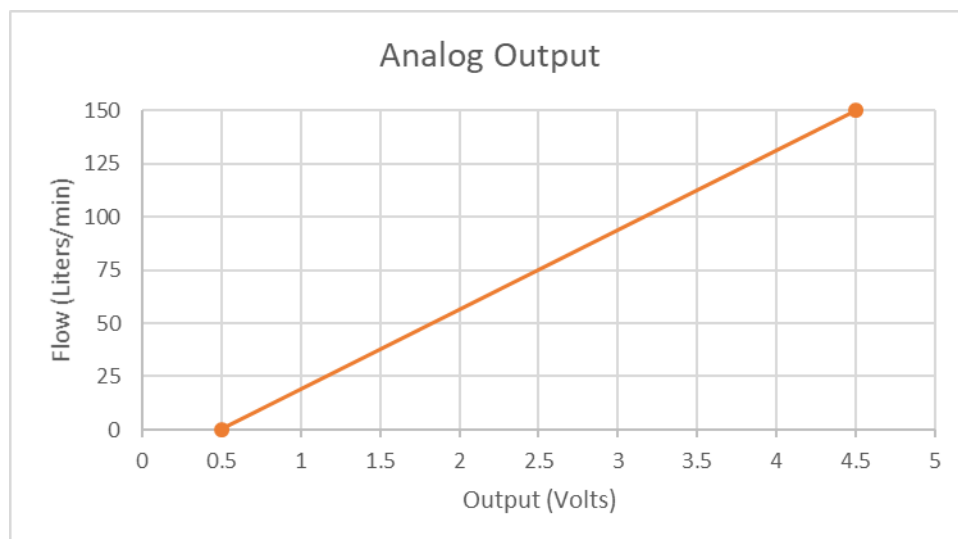
3. Flow Graphs

The graphs in Figure 2 and Figure 3 shows the digital and analog output versus flow, at 25°C, with nitrogen.



| Flow (Liters/min) | Digital Output (Counts) |
|-------------------|-------------------------|
| 0 | 409 |
| 150 | 3686 |

Figure 2. Digital Output



| Flow (Liters/min) | Analog Output (Volts) |
|-------------------|-----------------------|
| 0 | 0.5 |
| 150 | 4.5 |

Figure 3. Analog Output

4. I²C Sensor Interface

The FS1025-DG includes a digital I²C two-wire interface with a bidirectional data line (SDA) and a clock line (SCL). The two lines are open drain and connected to the supply voltage via two pull-up resistors (Rp). The FS1025-DG operates as a slave device on the I²C bus with support of 100kHz and 400kHz bit rates.

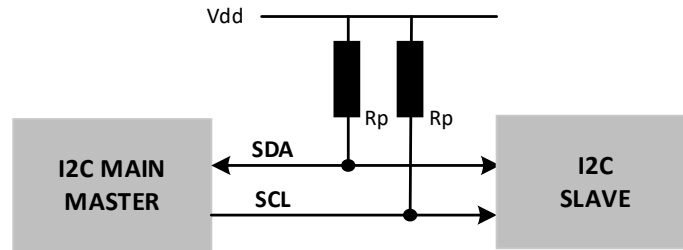


Figure 4. I²C Master-Slave Configuration

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

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

4.1 Sensor Slave Address

The FS1025-DG default I²C address is 50_{HEX}. The device will respond only to this 7-bit address.

4.2 I²C Communication

The START condition is used to initiate I²C 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 I²C 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 I²C 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.

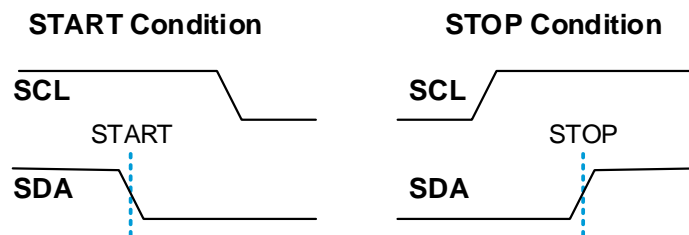


Figure 5. START and STOP Condition Waveform

4.3 Digital Output Measurements

The FS1025-DG 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 FS1025-DG.

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 FS1025-DG (slave) to master (see Figure 6).

The checksum used for data integrity is returned from the FS1025-DG 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 7).

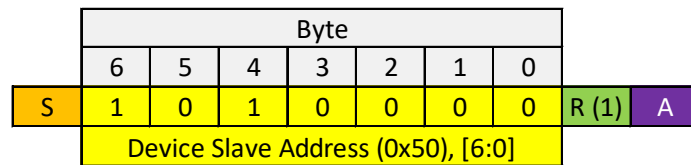


Figure 6. Flow Data Read Command

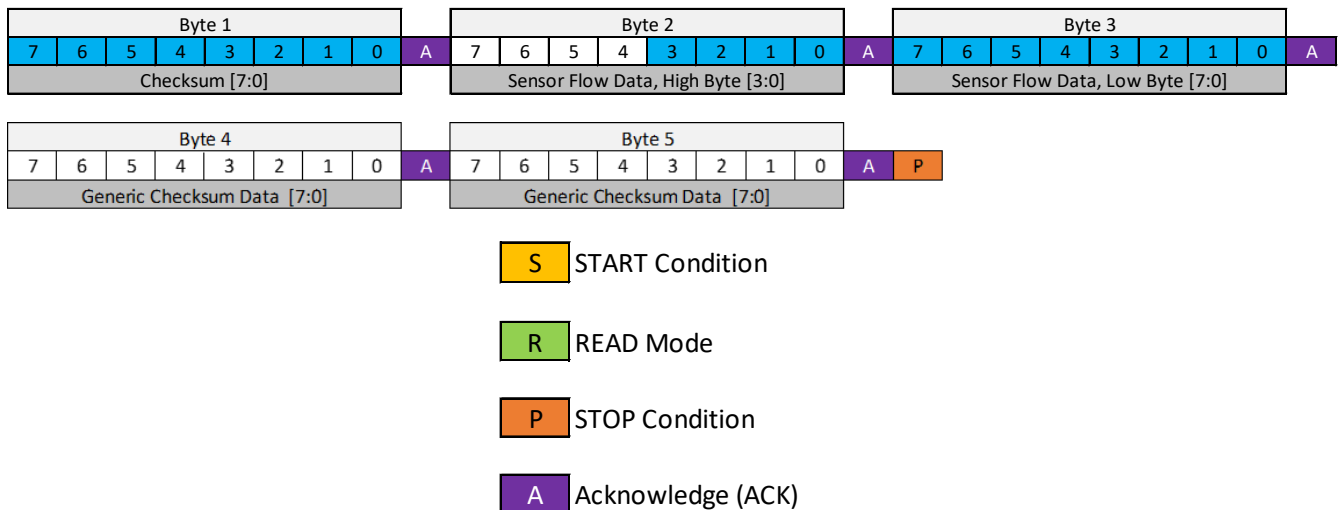


Figure 7. Flow Data from FS1025-DG

4.4 Calculating Flow Output

The flow rate for the digital and analog output are calculated with Equation 1 and Equation 2, respectively.

$$Flow\ rate\ (liters/min) = \frac{Output\ (counts) - 409}{3277} * 150 \tag{Equation 1}$$

$$Flow\ rate\ (liters/min) = \frac{Output\ (analog) - 0.5}{4} * 150 \tag{Equation 2}$$

4.5 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 I2C 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:

$$sum = 0x01 + 0x99 + 0x01 + 0x99 = 0x134$$

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.

$$checksum + sum = 0xCC + 0x134 = 0x00$$

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).

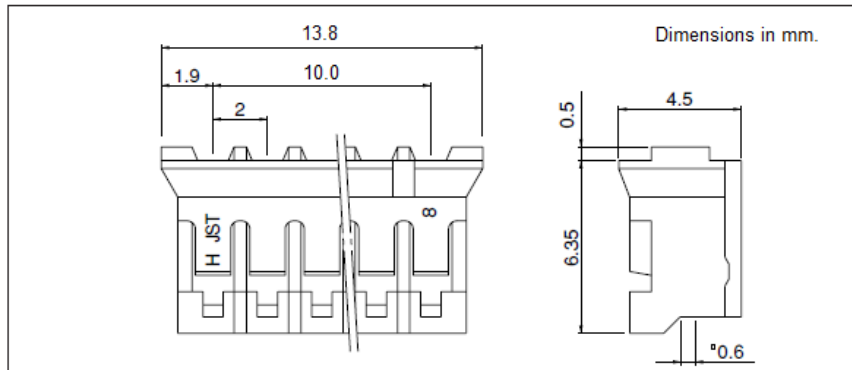


Figure 8. Receptacle Drawing

6. Module Material

The wetted contact surface of the FS1025-DG consists of the following:

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

7. Tubing Guidance

The FS1025-DG module has barb tube endings. Soft tubing with a nominal 7/16-inch (11.1mm) internal diameter is recommended for use. A clamp may be necessary to secure the tubing over the barb.

8. Package Outline Drawings

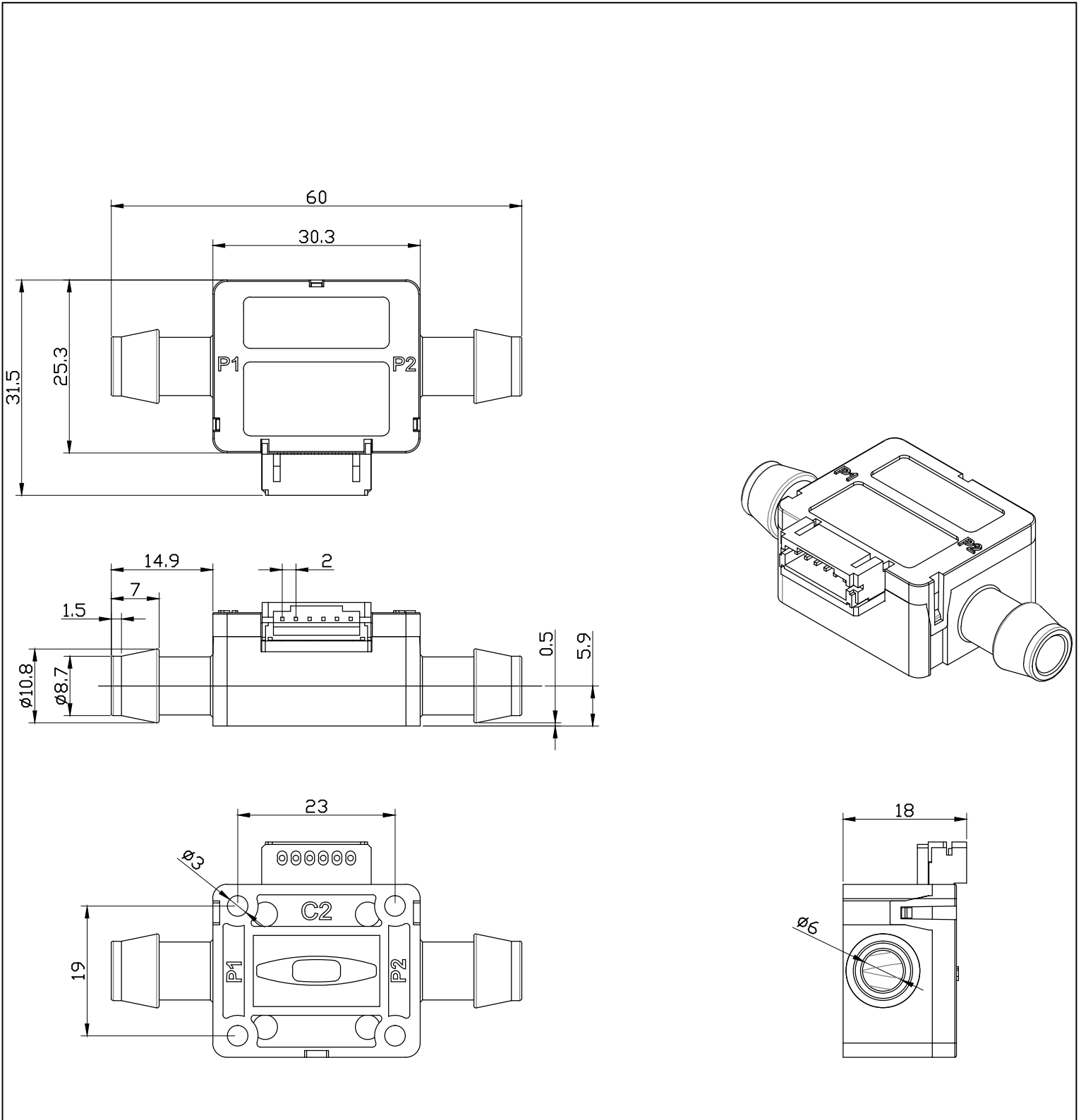
The package outline drawings are located at the end of this document and are accessible from the Renesas website. The package information is the most current data available and is subject to change without revision of this document.

9. Ordering Information

| Part Number | Package Description | Carrier Type | Temperature Range |
|----------------|--|--------------|-------------------|
| FS1025-1001-DG | 0 to 150 liter/min liquid flow sensor module with digital and analog voltage output (see MOD01) | Box | 0° to +85°C |

10. Revision History

| Revision | Date | Description |
|----------|--------------|--|
| 1.03 | May 3, 2023 | <ul style="list-style-type: none"> ▪ Added maximum pin ratings to Absolute Maximum Ratings ▪ Added I2C Electrical Specifications |
| 1.02 | Sep 2, 2022 | Updated reference with nitrogen gas. Reformatted to the latest template. |
| 1.01 | Sep 25, 2020 | Updated flow accuracy spec, flow output charts, and checksum example. |
| 1.00 | Apr 28, 2020 | Initial release. |



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

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