# FLS122 Air Velocity Sensor Datasheet

## Highlights

- Silicon-MEMS air velocity sensor
- Operating range up to 20 ms$^{-1}$
- Firmware running on a standard microcontroller provides digital flow velocity and temperature readings
- Fully temperature-compensated readings
- Firmware-configurable operating modes and features allow you to tailor FLS122-based solutions for your application
- Ultra-small surface mount package enables easy integration in space-constrained locations
- Fully compatible with standard SMD assembly processes
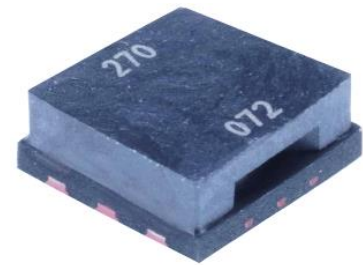
6-pin DFN package
Footprint 3.5 mm × 3.5 mm
Height less than 1.65 mm

FLS122 is ideal for consumer appliances and industrial applications in which air velocity measurement brings increased energy efficiency, minimization of fan noise and early detection of system failure. For example

- Thermal management and immediate detection of cooling air flow reduction/failure in high performance gaming PCs and data centre equipment racks
- Filter monitoring in vacuum cleaners and HVAC systems
- Control of variable air volume (VAV) dampers in HVAC systems

## Digital flow velocity sensing solutions with FLS122

The FLS122 has a MEMS die with thermal sensing elements for measuring flow rate and temperature. Firmware provided by Flusso, running on a standard microcontroller, drives the sensing elements of the FLS122, digitises their response and calculates readings for flow velocity and temperature.

Figure 1 illustrates the FLS122 (shown in cross section), mounted on a substrate and positioned in the system flow path with firmware running on a dedicated microcontroller. Application software on the host processor controls the FLS122 firmware and obtains readings over a serial digital interface. Standard FLS122 firmware (available from Flusso) implements I$^2$C-bus® with register read and write operations.
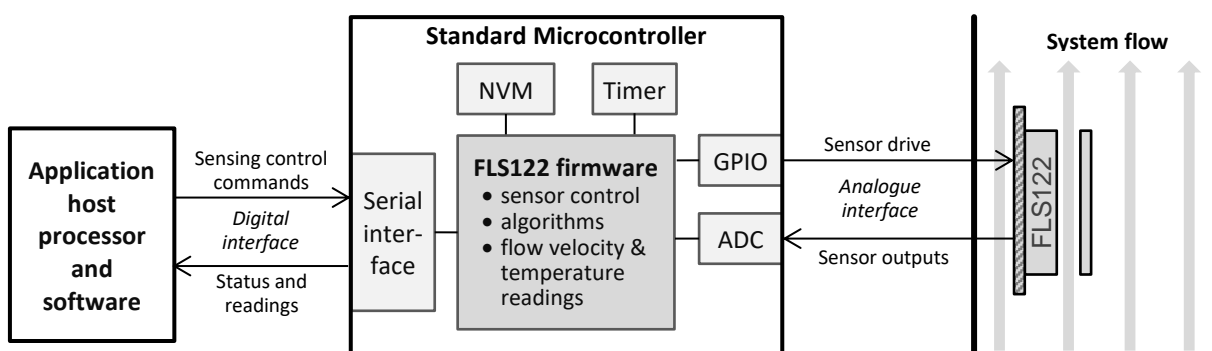


**Figure 1:** Example of an FLS122 digital flow velocity sensing solution with dedicated microcontroller

With its tiny footprint, the FLS122 can readily be integrated in the flow path of your product – whatever its shape and size – at the most effective or critical location for measuring velocity.

Calibration functions supported in the FLS122 firmware enable straightforward optimisation of FLS122-based solutions to your system's flow characteristics and your velocity measurement accuracy requirements.

If you already have a microcontroller in your system design, the FLS122 firmware can be compiled and linked with your application code using a software development kit (SDK) provided by Flusso. Instead of a serial interface, your application then uses API calls to control the FLS122 and obtain readings.

# 1 Sensing performance

Unless otherwise stated, sensing performance is specified at mean ±3σ under these standard conditions:

- FL-001982-PT FLS122-STM32 Air Velocity Sensor Electronics Module with VDD = 3.3 V (see section 4)
- 25 °C ambient ($T_{amb}$) and flow ($T_{flow}$) temperature
- FLS1x2 standard $I^2C$ firmware (ref. FL-002182-FW) operating in Continuous mode
- Each reading reported with averaging over 16 measurements
- Clean air in flow up to 20 ms$^{-1}$ with ambient pressure $p_{flow}$ = 101.3 kPa, relative humidity $\phi_{flow}$ = 0 %,
- Flow temperature sensor offset determined at $T_{ref}$ = 25 °C (see section 4.6.1)
- Three-point system calibration and cubic curve fit (see section 4.6.2)

## 1.1 Flow velocity readings

| Parameter | | | Units | Note |
|---|---|---|---|---|
| Repeatability | Zero flow | 0.1 | ms$^{-1}$ | Equivalent to 0.5% of full scale (f.s.) |
| | Span | 0.5 | % m.v. | % of measured value |
| Accuracy | Zero flow | 0.1 | ms$^{-1}$ | Equivalent to 0.5% of full scale (f.s.) |
| | Span | 3 | % m.v. | % of measured value |
| Temperature dependence | Zero flow | TBC | ms$^{-1}$/°C | |
| | Span | TBC | % m.v./°C | Multiply by \| $T_{ref}$ − $T_{flow}$ \| in °C |

## 1.2 Flow temperature ($T_{flow}$) readings

Typical performance is specified for

- $T_{flow}$ = $T_{amb}$ stable in the range -20 °C to +85 °C (equilibrium conditions).
- Flow velocity in the range 0 to 20 ms$^{-1}$

Note: flow temperature measurements are affected by the thermal environment in your product.

| Parameter | | | Units | Note |
|---|---|---|---|---|
| Repeatability | | 0.5 | °C | |
| Accuracy | At $T_{flow}$ = $T_{ref}$ | ±2 | °C | See section 4.6.1 |
| | Span | ±3 | % m.v./°C | Multiply by \| $T_{ref}$ − $T_{flow}$ \| in °C |

# 2 Normal operating conditions

Device reliability might be compromised if the FLS122 is operated outside the conditions specified in Table 1.

**Table 1:** Normal operating conditions

| Parameter | Symbol | Min | Max | Units | Notes |
|---|---|---|---|---|---|
| Ambient temperature | $T_{amb}$ | -20 | +85 | ºC | In most situations, ambient and flow temperature will be the same |
| Flow temperature | $T_{flow}$ | -20 | +85 | °C | |
| Humidity in the flow | $\phi_{flow}$ | | 90 | %RH | Non-condensing |
| Gas in flow | Air. Contact Flusso about measuring the flow velocity of other gases. | | | | |

# 3   Absolute maximum ratings

Permanent damage might result from exposure to conditions in excess of those specified in Table 2.
FLS122 is not qualified for sensing liquid flow velocity. Liquids can cause permanent damage to the device.

**Table 2:** Absolute maximum ratings

| Parameter | Symbol | Min | Max | Units | Notes |
|---|---|---|---|---|---|
| Storage temperature | $T_{store}$ | -40 | +85 | ºC | |
| Storage humidity | $\phi_{storage}$ | | 90 | %RH | Non-condensing |
| Ambient temperature | $T_{amb}$ | -40 | +85 | ºC | In most situations, ambient and flow temperature will be the same |
| Flow temperature | $T_{flow}$ | -40 | +85 | ºC | |
| Ambient humidity | $\phi_{amb}$ | | 90 | %RH | Non-condensing. In most situations, ambient and flow humidity will be the same. |
| Flow humidity | $\phi_{flow}$ | | 90 | %RH | |
| Voltage between pins | $V_{in}$ | | 3.6 | V | Between any two functional pins. See section 5. |
| Power dissipation | $P_{MAX}$ | | 50 | mW | Due to current flowing into the VH pin (see sections 4 and 5) |
| Electrostatic discharge | | | 500 | V | Human body model, JS-001-2017 |
| | | | 1000 | V | Charged device model, JS-002-2018 |

## 4 FLS122-STM32 reference design

Sensing functionality and performance specifications (see section 1) are achieved with an electronics module implementation of the FLS122-STM32 reference design running Flusso's *FLS1x2-STM32 Sensor Module Standard I2C Firmware* (FL-002182-FW). Two variants are available for FLS122 Evaluation Kits:

- FL-001982-PT FLS122-STM32 Air Velocity Sensor Electronics Module
- FL-002023-PT FLS122-STM32 Air Velocity Sensor Electronics Module with Pressure Sensor

### 4.1 Electronic hardware design

The FLS122-STM32 reference design schematic and the Air Velocity Sensor Electronics Module are shown Figure 2, below. The firmware runs on a STMicroelectronics™ STM32L031G6U6 microcontroller. It operates the analogue interface of the FLS122 and presents an I$^2$C target interface to a host via the 10-way connector. Refer to datasheet DS10668 and the STM32L0x1 Reference Manual RM0377 for full information about the processor.
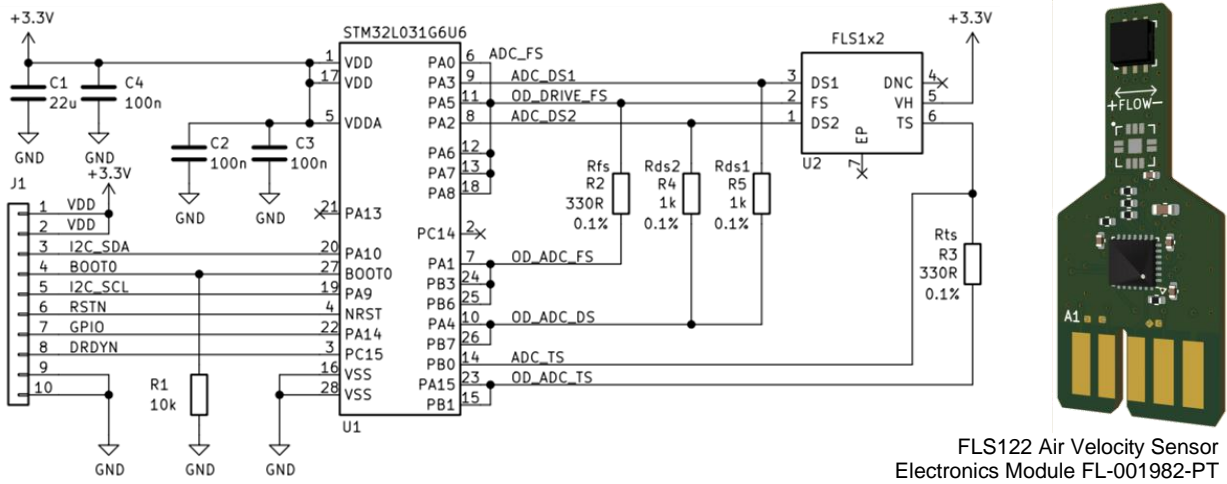


FLS122 Air Velocity Sensor
Electronics Module FL-001982-PT

**Figure 2:** FLS122-STM32 reference design schematic and module implementation

The FLS122 flow sensor pin FS is pulse-driven by the firmware, with pulse width modulation (PWM). To deliver the peak current requirement, a number of open-drain outputs of the microcontroller are connected in parallel. The connector pin functions are summarised in Table 3, below.

**Table 3:** FLS122-STM32 reference design connector pin definitions

| Pins | Name | Description |
|------|------|-------------|
| 1,2 | VDD | Power supply. Connected to the microcontroller VDD/VDDA and the FLS122 VH pin. |
| 3 | I2C_SDA | I$^2$C-bus data. A pull-up resistor (2.2 kΩ to 4.7 kΩ) is required on the host side. |
| 4 | BOOT0 | Drive high during power-up to load a firmware image over the I$^2$C-bus |
| 5 | I2C_SCL | I$^2$C-bus clock. A pull-up resistor (2.2 kΩ to 4.7 kΩ) is required on the host side. |
| 6 | RSTN | Pull low to reset the processor. |
| 7 | GPIO | A general-purpose IO, not used by the standard FLS122 firmware. |
| 8 | DRDYN | Open drain. Pulled low when a new reading is ready or certain firmware operations complete (see section 4.5.3). A pull-up resistor (2.2 kΩ to 4.7 kΩ) is required on the host. |
| 9,10 | GND | System ground (0 V). |

## 4.2 Hardware / firmware operating parameters

The main operating parameters of the FLS122-STM32 reference design are listed in Table 4. Some are referred to in explanations of firmware functionality in sections that follow.

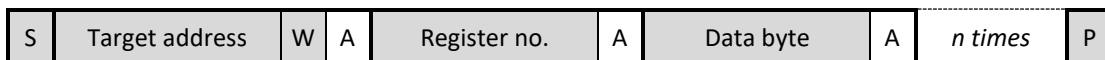**Table 4:** FLS122-STM32 reference design operating parameters

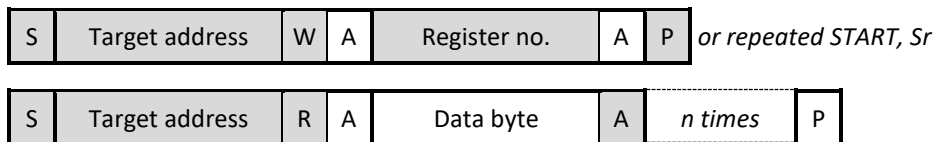| Parameter | | Symbol | Min | Typ | Max | Units | Comment |
|---|---|---|---|---|---|---|---|
| Power supply | | VDD | 3.0 | 3.3 | 3.6 | V | |
| Total current consumption (including the STM32L031 micro) | | $I_{DD\_CONT}$ | | | 15 | mA | Continuous or Single Shot mode |
| | | $I_{DD\_IDLE}$ | | | 2 | µA | In Idle mode |
| Power-up / reset time | | $t_{start}$ | | | 10 | ms | After which I²C interface is ready |
| I²C clock (I2C_SCL) frequency | | $f_{I2C}$ | | | 400 | kHz | Depending on application design |
| Continuous mode | Reading update rate | | | 500 | | Hz | |
| | Time to next reading | $t_C$ | | 2 | | ms | |
| Time to first reading in Continuous mode or to new Single Shot reading | | $t_{FSS}$ | | 56 + 2n | | ms | Where n is the number of measurements being averaged |

## 4.3 Standard firmware I²C registers

FLS1x2-STM32 Sensor Module Standard I2C Firmware (FL-002182-FW) presents registers that the host can read to obtain information and write to make settings and initiate firmware functions.

Figure 3 and Figure 4 illustrate write and read transactions. They follow the I²C-bus Specification and User Manual Rev. 7 nomenclature and shading conventions: transmissions from the controller are shaded grey, those from the target are unshaded. Multi-byte data values are little-endian.

- S is the I²C START condition
- The FLS122-STM32 reference design target address is 0x31 (7 bits)
- W is a WRITE bit, value '0'
- R is a READ bit, value '1'
- P is the I²C STOP condition
- A is the ACKNOWLEDGE bit, SDA low, or NOT ACKNOWLEDGE bit, SDA high

| S | Target address | W | A | Register no. | A | Data byte | A | *n times* | P |
|---|---|---|---|---|---|---|---|---|---|

**Figure 3:** I²C Register Write of n Bytes

| S | Target address | W | A | Register no. | A | P | *or repeated START, Sr* |
|---|---|---|---|---|---|---|---|

| S | Target address | R | A | Data byte | A | *n times* | P |
|---|---|---|---|---|---|---|---|

**Figure 4:** I²C Register Read of n Bytes

The I²C registers are summarised below in two groups:

- **Table 5:** I2C registers for controlling and obtaining information from the FLS1x2-STM32 firmware

- **Table 6:** I2C registers used for system-level calibration. Refer to technical note *FLS1xx Series System Characterisation and Calibration* for full information about the procedures that use of these registers.

In both tables the Data column gives the number of bytes transferred in an I²C read or write operation and the number format (U: unsigned integer, S: signed integer, F: IEEE 754 single precision floating point).

Further information about use of the registers is given in sub-sections that follow the tables.

**Table 5:** I²C registers for controlling and obtaining information from the FLS1x2-STM32 firmware

| Subgroup | Register | No. | Data | Description |
|---|---|---|---|---|
| **Static information** (section 4.4) | **FW_ID** | 0x10 | 3U | **Read** 0x0F100C, the FLS1x2-STM32 standard firmware ID |
| | **UNIQUE_ID** | 0x11 | 12U | **Read** The STM32L0 processor unique device ID |
| | **FW_BUILD** | 0x12 | 4U | **Read** Firmware build number |
| | **FW_RELEASE** | 0x13 | 4U | **Read** Firmware release number |
| **Firmware settings and status** (section 4.5) | **AVG_WINDOW** | 0x20 | 1U | **Write** The number of measurements in a moving average window to calculate readings:1 to 128, defaults to 1. **Read** The current moving average window size. |
| | **MODE** | 0x21 | 1U | **Write** Set mode 0: Idle, 1: Continuous,  2: Single Shot **Read** The current operating mode |
| | **READY** | 0x2F | 1U | **Read** Status of the latest reading or calibration step. 0: still in progress, 1: complete. See section 4.5.3. |
| | **PFLOW** | 0xE0 | 4U | **Write** Flow pressure ($p_{flow}$) in Pa. Defaults to 101325 Pa. **Read** The value last written, or the default if none written. Not needed for most applications. Refer to *FLS1xx Series System Characterisation and Calibration* for further information |
| **Readings and sensor information** (section 4.6) | **READING** | 0x40 | 4S | **Read** Flow velocity x 256, in the units used for calibration. See Figure 5 on page 9 for flow direction. |
| | **H** | 0x41 | 4S | **Read** Heat transfer coefficient ($h$) to the flow x $2^{32}$. |
| | **POWER** | 0x42 | 4U | **Read** Power in W x $2^{32}$ dissipated by the flow sensor during the last measurement period ($t_C$). |
| | **TFLOW** | 0x43 | 2S | **Read** $T_{flow}$ in °C x 256. |

**Table 6:** I²C registers used for system-level calibration procedures

| Register | No. | Data | Description |
|---|---|---|---|
| **TREF** | 0xFC | 2S | **Write** FLS122 device temperature $T_{ref}$ in °C x 256 to determine the $T_{flow}$ offset or 0x8000 to use microcontroller's on-chip temperature sensor. **Read** The temperature, $T_{ref}$ in °C x 256, at which $T_{flow}$ offset was determined, or 0x8000 if not done yet. |
| **ZEROPOINT** | 0xF0 | 4S | **Write** Any value to determine the zero-point reading offset **Read** Returns 0 if zero-point offset has been determined, 0xFFFF8000 if not |
| **SETPOINT1** … **SETPOINT10** | 0xF1 … 0xFA | 4S | **Write** 256 x the applied system flow velocity. See Figure 5 on page 9 for flow direction. Writing triggers a velocity measurement. **Read** The value that was previously written (0 if none has been written). |
| **CALIBRATE** | 0xFF | 1U | **Write** After writing to **SETPOINTn** registers, write 1 for single-point system calibration, 3 for cubic curve fit or 4 for quartic. $C_1$, $C_2$, $C_3$ and $C_4$ are then calculated from the measurements made at each setpoint. **Read** 3 after successful 3rd order calibration and curve fit, 4 for 4th order. Refer to *FLS1xx Series System Characterisation and Calibration* for troubleshooting other values. |
| **C1** **C2** **C3** **C4** | 0xC1 0xC2 0xC3 0xC4 | 4F | **Write** Values of coefficients to be set manually. **Read** Coefficient values previously calculated by a system calibration procedure (curve fit) or set manually. |
| **BASIS** | 0xCB | 1U | The mathematical basis for calculation of readings. Defaults to 0, which is suitable for most FLS122 applications. Refer to *FLS1xx Series System Characterisation and Calibration* for further information. |
| **NOTE0** | 0x50 | 4U | **R/W** Any number you choose, usually to identify calibration settings. |

## 4.4   Static information

The value in the **UNIQUE_ID** register is the concatenation of the U_ID registers of the STM32L031G6U6 microcontroller. Refer to the STM32L0x1 Reference Manual RM0377 for further information. It is useful as a unique ID or serial number for your FLS122 flow sensor module.

The values in the **FW_ID**, **FW_BUILD** and **FW_RELEASE** registers are defined in the firmware and can be customised if you wish, by building firmware using the SDK.

## 4.5   Firmware settings and status

### 4.5.1   Averaging of measurements (AVG_WINDOW register)

The firmware can be configured to take an average over a number of measurements for calculation of readings. Averaging is applied to flow velocity readings (in the **READING** register) and flow temperature measurements (in the **TFLOW** register). It is a moving window so does not affect the update rate in Continuous mode but increases the time taken for a first or Single Shot reading to be ready ($t_{FSS}$). In Idle mode, write the number of measurements to be included in the moving average to the **AVG_WINDOW** register, up to 128.

### 4.5.2   Operating mode (MODE register)

After power-up or reset the FLS1x2-STM32 firmware starts in **Idle mode** - power consumption is minimised, and no flow rate or flow temperature measurements are taken. Writing 1 to the **MODE** register changes the operating mode to Continuous mode, writing 2 triggers a Single Shot reading.

In **Continuous** mode the first flow velocity and temperature readings are ready after $t_{FSS}$. Thereafter they are updated at intervals of $t_C$. The firmware stays in Continuous mode until deliberately changed.

In **Single Shot** mode new flow velocity and temperature readings are ready after $t_{FSS}$ and the firmware automatically returns to **Idle** mode. This mode is useful for reducing average power consumption.

### 4.5.3   Operating status (READY register and DRDY signal)

Firmware operating status is available to the host by two means:

1.   Polling the I$^2$C **READY** register

2.   Using the active low **DRDYN** signal to trigger an interrupt

The **READY** register reads 1 and **DRDYN** is asserted (pulled low) when

- A new flow temperature reading is ready in the **TFLOW** register (see section 4.6.1)

- A new flow velocity reading is ready in the **READING** register (section 4.6.2)

- An offset or calibration step has completed (see technical note *FLS1xx Series System Characterisation and Calibration*)

The **READY** register reads 0 and **DRDYN** is de-asserted (set to high impedance) when

- Entering Continuous or Single Shot mode, by writing to the **MODE** register

- Flow temperature is read from the **TFLOW** register

- System flow velocity is read from the **READING** register

- Writing to any of the I$^2$C registers for system-level calibration (see Table 6)

### 4.5.4   Flow pressure (PFLOW register)

Flow pressure ($p_{flow}$) is used in the calculation of flow velocity readings (see section 4.6.2). The FLS122 does not have a built-in flow pressure sensor, instead the host application can write flow pressure (in pascals) to the **PFLOW** register at any time.

## 4.6 Readings and sensor information

Note: Content of the **READING**, **TFLOW**, **H** and **POWER** registers is only valid when the **READY** register reads 1 and **DRDYN** is asserted, as described section 4.5. Averaging, if selected using the **AVG_WINDOW** register, is applied to measurements to produce readings with less noise.

### 4.6.1 Flow temperature ($T_{flow}$) measurement

The FLS122 has a built-in temperature sensor that is driven and measured by the FLS122-STM32 reference design firmware via the TS pin (see section 4.1). Its output is digitised and used to:

- Provide flow temperature ($T_{flow}$) readings in °C for the host application via the **TFLOW** register.
- Temperature-compensate flow velocity measurements (see section 4.6.2)
- Calculate flow velocity readings (see section 4.6.2)

Conversion of the digitised output of the temperature sensor to Celsius (°C) or Kelvin (K) requires an offset term, which must be determined for every end-product unit using a simple procedure during your production test. The FLS22 must be at a known, stable temperature ($T_{ref}$), which your test system software writes to the **TREF** register. See technical note *FLS1xx Series System Characterisation and Calibration* for full information.

### 4.6.2 Flow velocity readings

The flow velocity sensing element of the FLS122 MEMS device is a heated tungsten wire. Readings are calculated as follows:

1. The coefficient of heat transfer (*h*) from the heated wire to the flow is calculated with compensation for flow temperature ($T_{flow}$). A **zero-point offset** is applied so that *h* is close to zero with no flow.

2. *h* increases monotonically but not linearly with flow velocity. Readings on a linear scale are calculated as a polynomial function of *h*:

$$\bar{v} = C_4 h^4 + C_3 h^3 + C_2 h^2 + C_1 h$$

Procedures for determination of the **zero-point offset** and the coefficients $C_4, C_3, C_2$ and $C_1$ described in the technical note *FLS1xx Series System Characterisation and Calibration*.

The heat transfer coefficient (*h*) is made available to the host application via the I²C **H** register. Readings are made available via the **READING** register. The units in which readings are provided is set during end-product unit **calibration**. This is explained in technical note *FLS1xx Series System Characterisation and Calibration*.

The accuracy specified in section 1.1 is achieved with calibration using three non-zero flow setpoints and cubic curve fit (i.e., $C_4 = 0$). Alternatively, a quartic curve fit with four or more non-zero calibration setpoints (up to ten) can be selected during calibration. This can be used to obtain good accuracy over an extended range of operation and/or cope with particular system flow characteristics.

### 4.6.3 Flow velocity sensing power consumption

The average power dissipated by the FLS122 flow sensing element during the last measurement period ($t_C$) is made available in the **POWER** register. This information can be useful if you wish to experiment with the trade-off between power consumption and the frequency at you take flow velocity readings in Single Shot mode.

## 5   Pin assignments and flow direction

FLS122 device pin assignments and positions are shown in Table 7, below.

**Table 7:** Pin assignments

| Pin | Name | Function |
|-----|------|----------|
| 1 | DS2 | Flow sensor connection. |
| 2 | FS | Flow sensor connection. |
| 3 | DS2 | Flow sensor connection. |
| 4 | - | Solder pad only. Do not connect. |
| 5 | VH | Supply pin (V high) |
| 6 | TS | Flow temperature sensor connection. |
| 7 | - | Solder pad only. Do not connect. |

FLS122 pin positions and flow direction are shown in Figure 5.
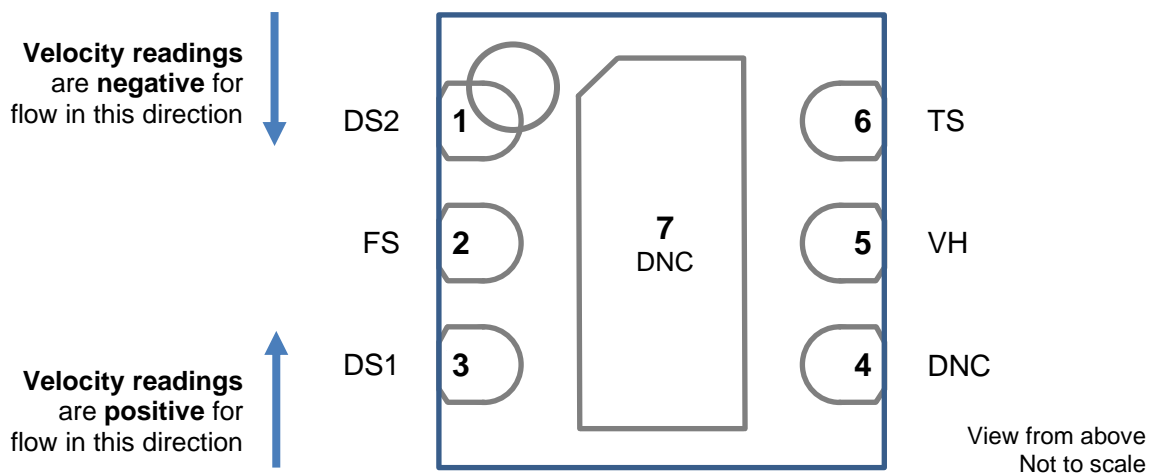


**Figure 5:** Pin positions and flow direction / sign of

# 6   Package dimensions and marking
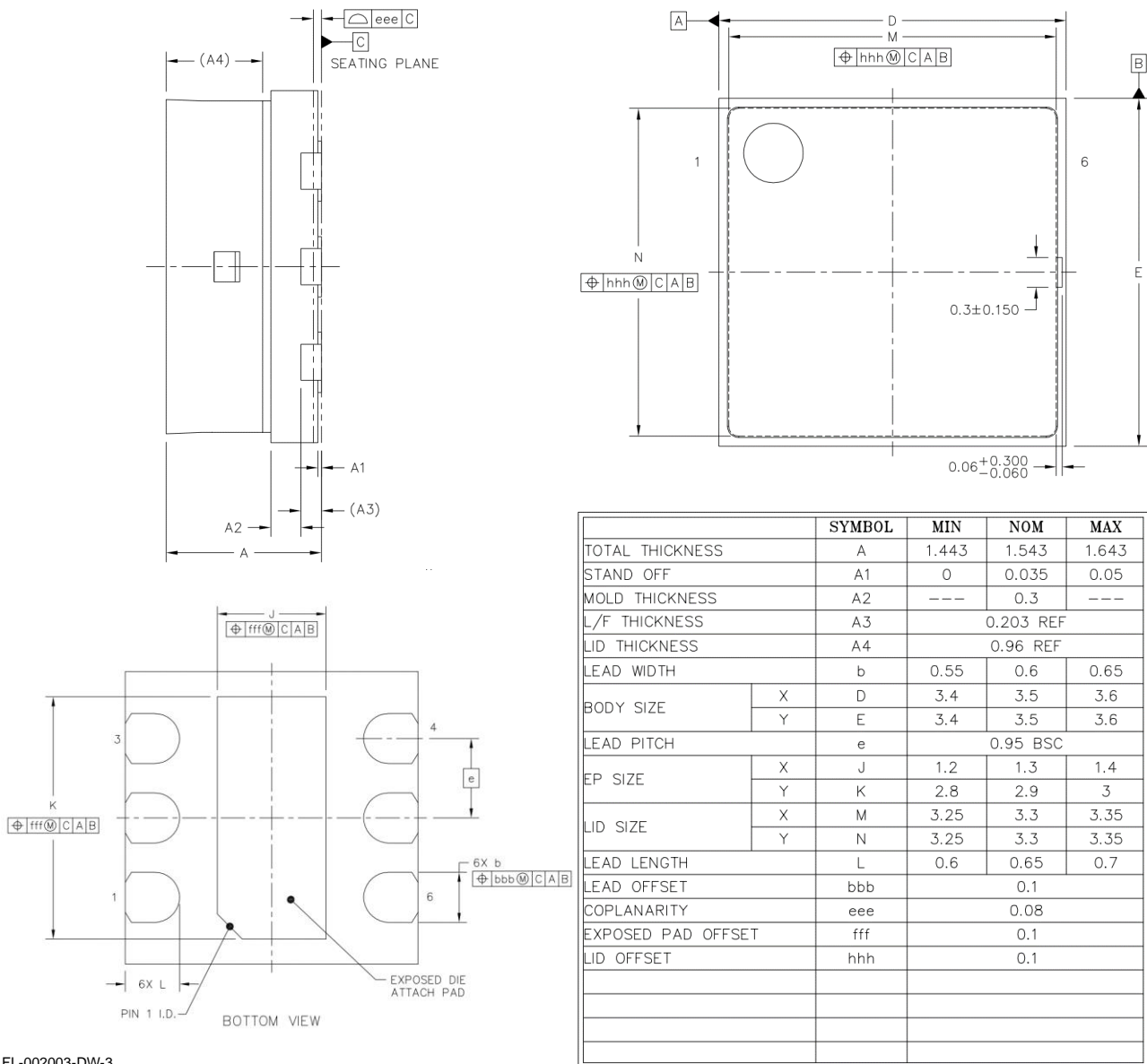


**Figure 6:** Package dimensions

| | | SYMBOL | MIN | NOM | MAX |
|---|---|---|---|---|---|
| TOTAL THICKNESS | | A | 1.443 | 1.543 | 1.643 |
| STAND OFF | | A1 | 0 | 0.035 | 0.05 |
| MOLD THICKNESS | | A2 | --- | 0.3 | --- |
| L/F THICKNESS | | A3 | | 0.203 REF | |
| LID THICKNESS | | A4 | | 0.96 REF | |
| LEAD WIDTH | | b | 0.55 | 0.6 | 0.65 |
| BODY SIZE | X | D | 3.4 | 3.5 | 3.6 |
| | Y | E | 3.4 | 3.5 | 3.6 |
| LEAD PITCH | | e | | 0.95 BSC | |
| EP SIZE | X | J | 1.2 | 1.3 | 1.4 |
| | Y | K | 2.8 | 2.9 | 3 |
| LID SIZE | X | M | 3.25 | 3.3 | 3.35 |
| | Y | N | 3.25 | 3.3 | 3.35 |
| LEAD LENGTH | | L | 0.6 | 0.65 | 0.7 |
| LEAD OFFSET | | bbb | | 0.1 | |
| COPLANARITY | | eee | | 0.08 | |
| EXPOSED PAD OFFSET | | fff | | 0.1 | |
| LID OFFSET | | hhh | | 0.1 | |

FL-002003-DW-3



**Figure 7:** FLS122 package marking (not to scale)

**tt**     FLS122 sample or product type number

**xxxx**   alphanumeric assembly traceability code

## 7   Handling and surface mount assembly

FLS112 should be handled in accordance with IPC/JEDEC J-STD-033B.1 for devices with Moisture Sensitivity Level 3.

FLS122 is supplied on tape and reel. It can be picked and placed with standard tools and equipment but vacuum should not be applied to the open ports.

Flusso recommends an IPC/JEDEC J-STD-020E Pb-Free Assembly infra-red (forced convection) reflow profile with $T_P \leq 250$ °C and time $t_p$ above 245 °C not exceeding 30 seconds. Ensure that solder and flux do not enter the FLS122 during reflow.

Vapour phase reflow soldering is not recommended because of the risk of contamination via the ports.

The FLS122 should be protected from ingress of liquid or particulate contaminants during handling and assembly processes, for example solvent cleaning, blown air cleaning and PCB singulation.

## 8   Materials and disposal

FLS122 complies with RoHS, REACH and halogen-free requirements.

Like any unwanted electronic device, FLS122 components should be recycled or otherwise disposed of in accordance with local regulations.

## 9   Ordering and packing information

| Product | Packing Type | Size | Quantity | Order code | Comment |
|---------|--------------|------|----------|------------|---------|
| FLS122 | Tape & reel | 7" | 500 | FLS-122-TR07 | Full reels only |
|  | Waffle tray | 100 mm x 100 mm | 324 (max) | FLS-122-WT324 | Sample quantities only |

## Datasheet Status

The status of this datasheet is shown in the footer. Please visit www.flussoltd.com to obtain the most recently issued version and other product information.

| Datasheet Status | Product Status | Datasheet Content |
|---|---|---|
| Preview | Development | Target specifications for development of the product. Specifications, designs, and descriptions provisional and subject to confirmation. Flusso reserves the right change specifications or discontinue development of the product without notice. |
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