

# Product Specification

## Senseair S88 Residential

Miniature CO<sub>2</sub> sensor with NDIR technique



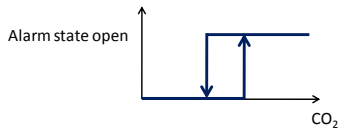
| Item                                                       | Senseair S88 Residential Article No. 004-1-0100                                                                                                                                                                                 |
|------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Operating principle                                        | Non-dispersive infrared (NDIR)                                                                                                                                                                                                  |
| Measured gas                                               | Carbon dioxide (CO <sub>2</sub> )                                                                                                                                                                                               |
| Measurement range                                          | 400–10000ppm <sup>1, 2</sup>                                                                                                                                                                                                    |
| Measurement interval                                       | 2s                                                                                                                                                                                                                              |
| Accuracy [CO <sub>2</sub> ]<br>(ANSI/ASHRAE Standard 62.1) | 400–2500ppm: ±75ppm <sup>3</sup>                                                                                                                                                                                                |
| Accuracy [CO <sub>2</sub> ]<br>(Operating conditions)      | 400–3000ppm: ±50ppm ±3% of reading <sup>4, 5</sup><br>3000–10000ppm: ±10% of reading <sup>4, 5</sup>                                                                                                                            |
| Operating conditions                                       | 0–50 °C, 0–85% RH (non-condensing, dew point ≤35°C)                                                                                                                                                                             |
| Warm-up time                                               | < 10s <sup>6</sup>                                                                                                                                                                                                              |
| Response time $\tau_{63\%}$                                | ≤ 30s                                                                                                                                                                                                                           |
| Power supply                                               | 4.5–5.25V unprotected against surges and reverse connection                                                                                                                                                                     |
| Peak current                                               | ≤ 300mA                                                                                                                                                                                                                         |
| Average current, typical                                   | ≤ 30mA                                                                                                                                                                                                                          |
| Communication                                              | UART, Modbus protocol <sup>7</sup> . Direction control pin for direct connection to RS485 receiver integrated circuit.                                                                                                          |
| Alarm output, open collector                               |  <p>1000 / 800ppm Normal state is conducting typ 10mA.<br/>Transistor open at CO<sub>2</sub> High, OR<br/>Power Low, OR at Sensor failure</p> |
| PWM output, 1kHz                                           | 0–100% duty cycle for 0–2000ppm<br>3.3V push-pull CMOS output, unprotected                                                                                                                                                      |
| Pressure dependence                                        | 1.6% reading per kPa deviation from normal pressure                                                                                                                                                                             |
| Compliance                                                 | ANSI/ASHRAE Standard 62.1-2022<br>+Addendum ab (October 31, 2023)<br>RESET grade B<br>WELL Building Standard® (WELL v2™)<br>Title 24, California Energy Code                                                                    |
| Maintenance                                                | Maintenance-free when using Senseair ABC algorithm (Automatic Baseline Correction).                                                                                                                                             |
| Life expectancy                                            | > 15 years                                                                                                                                                                                                                      |
| Dimensions (LxWxH)                                         | 33.9x19.8x8.7mm                                                                                                                                                                                                                 |
| Weight                                                     | < 5g                                                                                                                                                                                                                            |
| Storage conditions                                         | -40–70 °C                                                                                                                                                                                                                       |

Table 1. Key technical specification for the Senseair S88 Residential

Note 1: Sensor is designed to measure in the range 400–3000ppm with specified in the table accuracy. Exposure to concentrations below 400ppm may result in incorrect operation of ABC algorithm and shall be avoided for model with ABC ON.

Note 2: Sensor provides readings via UART in the extended range, but the accuracy is degraded compared to specification in the table one.

Note 3: ANSI/ASHRAE Addendum ab to ANSI/ASHRAE Standard 62.1-2022 specifies sensor to be accurate within ±75ppm at concentrations of 600, 1000, and 2500ppm when measured at sea level at 77 °F (25 °C). See Figure 4.

Note 4: In normal IAQ applications. Accuracy is defined after minimum three (3) ABC periods of continuous operation with ABC on. Some industrial applications do require maintenance. Contact Senseair for further information!

Note 5: Accuracy is specified over operating temperature range. Specification is referenced to certified calibration mixtures. Uncertainty of calibration gas mixtures (±1% currently) is to be added to the specified accuracy for absolute measurements.

Note 6: The time it takes from power supply voltage reaching nominal value to clear warm up bit in Error Status to 0 and to provide the first measurement value. See Table 7 for details on Error Status.

Note 7: See specification Modbus on Senseair S88, TDE14367.

## Description

Senseair S88 Residential is designed for high volume production with full traceability by sensor serial number on all manufacturing processes and key components. Every sensor is individually calibrated and is provided with UART digital interface. The sensor is maintenance-free and has an estimated lifetime of more than 15 years.

## Applications

Senseair S88 Residential is a module that is designed for simple integration into products. Senseair S88 Residential can be used in a wide range of applications such as ventilation control to improve energy savings and to assure a good indoor climate. Other fields of use are personal safety and measurements to increase process yield and to increase economic value in bio-related processes.

## Installation and soldering

See Handling manual for Senseair S8 and S88 (ANO102).

## Sample gas diffusion area

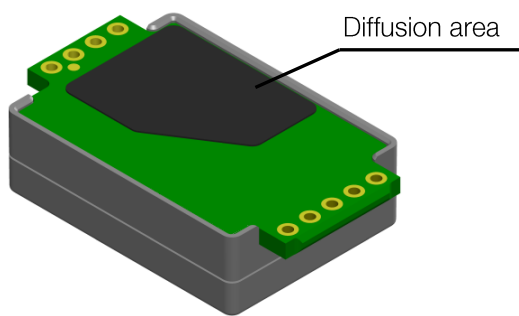


Figure 1. Diffusion area

## Pin Configuration and Functions



Figure 2. Pin assignment

## Pin Functions description

The table below specifies terminals and I/O options dedicated in Senseair S88 Residential model.

| Pin Function              | Pin description / parameter description                                                                                                                                                                                                              | Electrical specification                                                                                                                                                                                                                      |
|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Power pins</b>         |                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                               |
| G0                        | Power supply minus terminal<br>Sensor's reference (ground) terminal                                                                                                                                                                                  |                                                                                                                                                                                                                                               |
| G+ referred to G0         | Power supply plus terminal<br><br>Operating voltage range                                                                                                                                                                                            | Unprotected against reverse connection!<br>4.5–5.25V                                                                                                                                                                                          |
| DVCC_out                  | <u>Output</u><br>from sensor's voltage regulator<br>Output may be used to logical level converter if master processor runs at 5V supply voltage.<br><br>Series resistance<br>Nominal voltage<br>Allowed source current<br>Voltage precision (Note 1) | Induced noise or excessive current drawn may affect sensor performance. External series resistor is strongly recommended if this pin is used<br><br>No internal protection!<br>3.3VDC<br>6mA max<br>$\pm 0.75\%$ is typical, $\pm 3\%$ is max |
| <b>Communication pins</b> |                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                               |
| UART_TxD                  | UART data transmission line<br>Configured as digital output<br><br>Absolute max voltage range (Note 1)<br>Internal pull up to DVCC_out resistor<br>Output low level (Note 1)<br>Output high level (Note 1)                                           | No internal protection<br>Pulled up to DVCC_out at processor reset (power up and power down)<br>G0 - 0.3V to DVCC_out + 0.5V<br>120kOhm<br>0.5VDC max at 8mA sink<br>2.4VDC at 2mA source                                                     |
| UART_RxD                  | UART data receive line<br>Configured as digital input<br><br>Absolute max voltage range(Note 1)<br>Internal pull up to DVCC_out resistor<br>Input low level (Note 1)<br>Input high level (Note 1)                                                    | No internal protection<br>Pulled up to DVCC_out at processor reset (power up and power down)<br>G0 - 0.3V to DVCC_out + 0.5V<br>120kOhm<br>- 0.3–0.75V<br>2.3V to DVCC_out + 0.3V                                                             |
| UART_R/T                  | Direction control line for half duplex RS485 transceiver like MAX485.<br>Configured as digital output<br>Absolute max voltage range(Note 1)<br>Internal pull down to G0 resistor<br>Output low level (Note 1)<br>Output high level (Note 1)          | No internal protection,<br>Pulled down at processor reset (power up and power down)<br>G0 - 0.3V to DVCC_out + 0.5V<br>120kOhm<br>0.5VDC max at 8mA sink<br>2.4VDC at 2mA source                                                              |

Table 2. I/O notations, description and electrical specification (continued on next page).

| Pin function   | Pin description / parameter description                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Electrical specification                                                                                                                                                                                                                                                 |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Input / output |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                          |
| bCAL_in/ CAL   | <p>Digital input forcing background calibration. Configured as digital input (when closed for minimum 4, max 8 seconds) bCAL (background calibration) assuming 400ppm CO<sub>2</sub> sensor exposure</p> <p>Zero calibration (when closed for minimum 16 seconds) CAL (zero calibration) assuming 0ppm CO<sub>2</sub> sensor exposure</p> <p>Absolute max voltage range (Note 1)<br/>Internal pull up to DVCC_out resistor<br/>Input low level <sup>1</sup><br/>Input high level <sup>1</sup></p> | <p>No internal protection,<br/>Pulled up to DVCC_out at processor reset<br/>(power up and power down)</p> <p>G0 - 0.3V to DVCC_out + 0.5V<br/>120kOhm<br/>- 0.3–0.75V<br/>2.3V to DVCC_out + 0.3V</p>                                                                    |
| PWM 1kHz       | <p>PWM output<br/>Configured as digital output</p> <p>Used for direct reading by customer's microcontroller or to provide analog output.</p> <p>Duty cycle min<br/>Duty cycle max<br/>PWM resolution<br/>PWM period<br/>Absolute max voltage range <sup>1</sup><br/>Internal pull down to G0 resistor<br/>Output low level <sup>1</sup><br/>Output high level <sup>1</sup></p>                                                                                                                    | <p>No internal protection,<br/>Pulled down at processor reset<br/>(power up and power down)</p> <p>0%, output Low<br/>100%, output High<br/>0.5us ± 4%<br/>1ms ± 4%<br/>G0 - 0.3V to DVCC_out + 0.5V<br/>120kOhm<br/>0.5VDC max at 8mA sink<br/>2.4VDC at 2mA source</p> |
| Alarm_OC       | <p>Open Collector output for alarm indication</p> <p>Absolute max voltage range <sup>1</sup><br/>Internal pull up to G+ resistor<br/>Max sink current <sup>1</sup><br/>Saturation voltage <sup>1</sup></p>                                                                                                                                                                                                                                                                                        | <p>No internal protection,<br/>Pulled up to G+ at processor reset<br/>(power up and power down)</p> <p>G0 - 0.3V–5.5V<br/>10kOhm<br/>100mA<br/>0.3V at I sink = 10mA</p>                                                                                                 |

Table 2. I/O notations, description and electrical specification (continue, see previous page).

Note 1: Specified parameter relies on specification of subcontractor and is not tested by Senseair.

# Absolute maximum ratings

Stress greater than those listed in Table 2 may cause permanent damage to the device. These ratings are stress ratings only. Operation of the device at any condition outside those indicated in the operational section of these specifications is not implied. Exposure to absolute maximum rating for extended periods may affect device reliability.

| Parameter                                      | Minimum | Maximum        | Units | Notes |
|------------------------------------------------|---------|----------------|-------|-------|
| Ambient temperature under bias                 | -40     | 85             | C     |       |
| Voltage on G+ pin with respect to G0 pin       | -0.3    | 5.5            | V     | 1, 2  |
| Maximum output current from active output pin  | -25     | +25            | mA    | 1     |
| Maximum current on input                       | -5      | +5             | µA    | 1     |
| Maximum voltage on UART lines, PWM and bCAL_in | -0.3    | DVCC_out + 0.5 | V     | 1     |
| Maximum voltage on Alarm_OC                    | -0.3    | 12             | V     | 1, 3  |

Table 3. Absolute maximum ratings specification for the Senseair S88 Residential

- Note 1: Specified parameter relies on specification of subcontractor and is not tested by Senseair.
- Note 2: Refer chapter “Terminal description” for rated voltage information.
- Note 3: Alarm\_OC pin is internally pulled up to G+. External pull up to higher voltage will provide resistive divider powering sensor via high resistance.

# Recommended operating conditions

Over operating temperature range (unless otherwise noted)

| Symbol | Description    | Min | Typ | Max  | Unit | Test conditions |
|--------|----------------|-----|-----|------|------|-----------------|
| G+     | Supply voltage | 4.5 | 5   | 5.25 | V    |                 |

Table 4 Recommended operating conditions

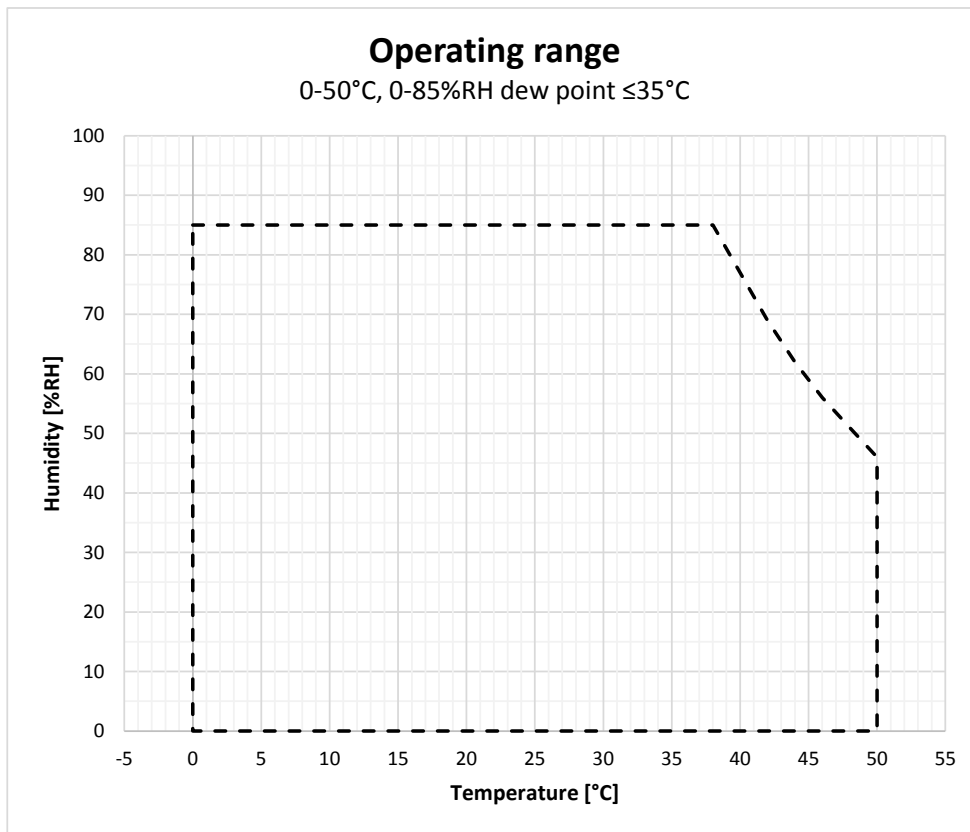


Figure 3 Operating range for specified in Table 1 accuracy.

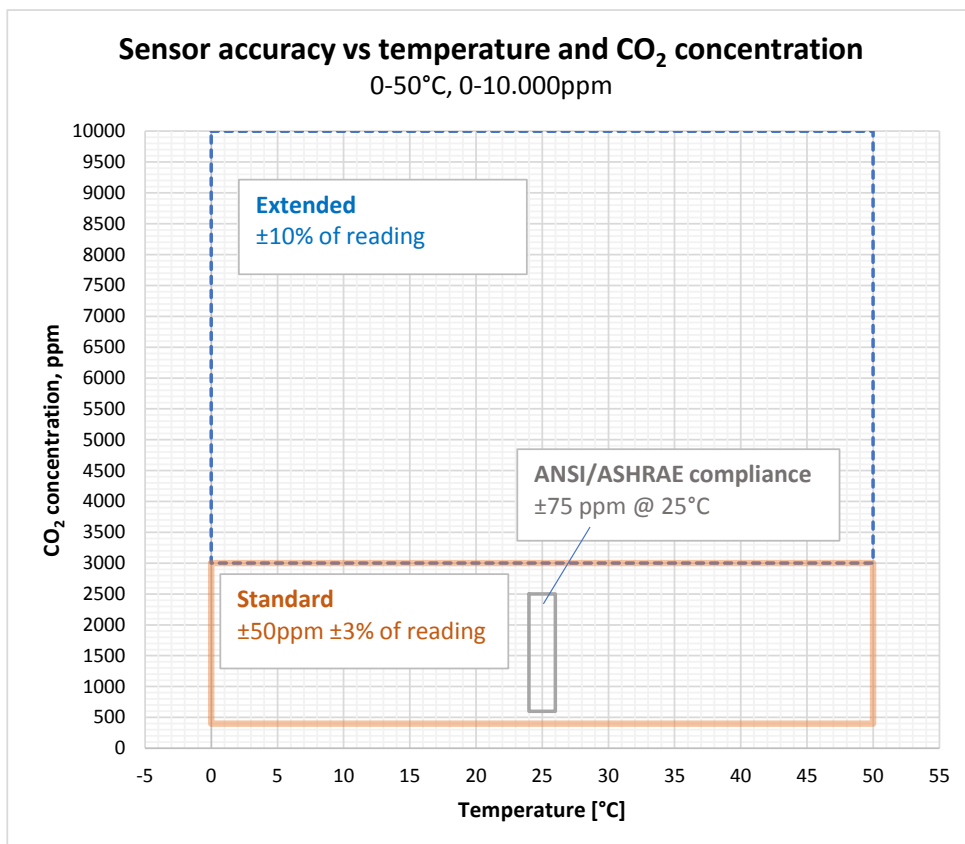


Figure 4 Accuracy over complete operating range (temperature and measurement of CO<sub>2</sub>).

## Mechanical properties

Refer to mechanical drawing for detailed specification of dimensions and tolerances.  
See Handling manual for Senseair S8 and S88 (ANO102).

## Maintenance and ABC (Automatic Baseline Correction)

The models based on Senseair S88 Residential platform are basically maintenance free in normal environments thanks to the built-in self-correcting ABC algorithm. This algorithm constantly keeps track of the sensor's lowest reading over preconfigured time interval and slowly corrects for any long-term drift detected as compared to the expected fresh air value of 400ppm (or 0.04%vol) CO<sub>2</sub>.  
Discuss your application with Senseair, in order to get advice for a proper calibration strategy.

When checking the sensor accuracy, NOTE that the sensor accuracy is defined at continuous operation (at least 3 ABC periods after installation with ABC turned on)!

| ABC parameter | Specification |
|---------------|---------------|
| ABC period    | 8 days        |

Table 5. ABC default configurations for Senseair S88 Residential

## Calibration

Rough handling and transportation might result in a reduction of sensor reading accuracy. With time, the ABC function will tune the readings back to the correct numbers. The default “tuning speed” is limited to about 30–50ppm / ABC period.

For post calibration convenience, in the event that one cannot wait for the ABC algorithm to cure any calibration offset two manual calibration procedures are offered. A switch input is defined for the operator or master system to select one of the two prepared calibration codes.

Optional calibrations are **bCAL** (background calibration), which requires that the sensor is exposed to fresh air (400ppm CO<sub>2</sub>) and **CAL** (zero calibration), which requires the sensor measuring cell to be completely evacuated from CO<sub>2</sub> e.g., by exposing it to Nitrogen or Soda Lime CO<sub>2</sub> scrubbed air. Make sure that the sensor environment is steady and calm!

| Input   | Default function                                                                                                            |
|---------|-----------------------------------------------------------------------------------------------------------------------------|
| bCAL_in | (when closed for minimum 4, max 8 seconds)<br>bCAL (background calibration) assuming 400ppm CO <sub>2</sub> sensor exposure |
| CAL_in  | (when closed for minimum 16 seconds)<br>CAL (zero calibration) assuming 0ppm CO <sub>2</sub> sensor exposure                |

Table 6. Switch input default configurations for Senseair S88 Residential

# Self-diagnostics

The system contains complete self-diagnostic procedures. A full system test is executed automatically every time the power is turned on. In addition, constantly during operation, the sensor probes are checked against failure by checking the valid dynamic measurement ranges. All EEPROM updates, initiated by the sensor itself, as well as by external connections, are checked by subsequent memory read back and data comparisons. These different system checks return error bytes to the system RAM. The full error codes are available from the UART communication port. *Out of range* error is the only bit that is reset automatically after return to normal state. All other error bits have to be reset after return to normal by UART overwrite, or by power off / on.

## Error code and action plan

(Error code can be read via UART communication port)

| Bit # | Error code | Error description                                                                                                                                                                             | Suggested action                                                                                                                                         |
|-------|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0     | 1          | <b>Fatal error</b>                                                                                                                                                                            | Try to restart sensor by power OFF / ON.<br>Contact local distributor.                                                                                   |
| 1     | 2          | <b>Reserved</b>                                                                                                                                                                               | -                                                                                                                                                        |
| 2     | 4          | <b>Algorithm error.</b><br>Indicate wrong configuration.                                                                                                                                      | Try to restart sensor by power OFF / ON.<br>Check detailed settings and configuration with software tools.<br>Contact local distributor.                 |
| 3     | 8          | <b>Output error</b><br>Detected errors during output signals calculation and generation.                                                                                                      | Check connections and loads of outputs.<br>Check detailed status of outputs with software tools.                                                         |
| 4     | 16         | <b>Self-diagnostic error.</b><br>May indicate the need of zero calibration or sensor replacement.                                                                                             | Check detailed self-diagnostic status with software tools. Contact local distributor.                                                                    |
| 5     | 32         | <b>Out of range error</b><br>Accompanies most of other errors. Can also indicate overload or failures of sensors and inputs.<br><br>Resets automatically after source of error disappearance. | Try sensor in fresh air.<br>Perform CO <sub>2</sub> background calibration.<br>Check detailed status of measurements with software tools.<br>See Note 1! |
| 6     | 64         | <b>Memory error</b><br>Error during memory operations.                                                                                                                                        | Check detailed settings and configuration with software tools.                                                                                           |
| 7     | 128        | <b>Warm Up</b><br>Set to 1 until first unfiltered reading is available from the sensor.                                                                                                       | Normal operation to have it during warm up time, see Table 1 for details.                                                                                |

Table 7. Error codes for Senseair S88 Residential

**Note 1.** Any probe is out of range. It occurs, for instance, during over-exposure of CO<sub>2</sub> sensor, in which case the error code will automatically reset when the measurement values return to normal. It could also indicate the need of zero-point calibration. If the CO<sub>2</sub> readings are normal, and still the error code remains, any other sensor probe mounted (if any) can be defect, or the connection to this probe is broken.

If several errors are detected at the same time the different error code numbers will be added together into one combined error code!

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