

# Product Specification

## aSENSE VAV

CO<sub>2</sub> / temperature sensor with built-in general purpose controller



### General

The IAQ-sensor product aSENSE VAV is used to measure indoor air carbon dioxide concentration and temperature. It is a very flexible controller with programmable outputs for both relay- and linear control of e.g. mixed air dampers, humidifier and fans. The measured values are shown on the display.

The linear output functions are pre-programmed for different ventilation strategies for stand-alone control. The units can alternatively be connected to common VAV (Variable Air Volume) controllers, or Direct Digital Control (DDC). All functions can be modified from a PC with the RS232 communication cable.

Item	aSENSE specification
Measured gas	Carbon dioxide (CO <sub>2</sub> )
Operating Principle	Non-dispersive infrared (NDIR) waveguide technology
OUT1 MAX function of CO <sub>2</sub> and temperature	0–10VDC, programmable output pre-programmed as control signal of demand of coolness and air quality (with reduced flow by extreme cold)
OUT2 CO <sub>2</sub>	0–10VDC, programmable output pre-programmed 600-900 ppm CO <sub>2</sub>
OUT3	Relay pre-programmed ON/OFF 600/500ppm CO <sub>2</sub>
OUT4	0–10VDC or open collector, control signal of heat demand pre-programmed PWM, 18-20°C, inverted input
Accuracy CO <sub>2</sub>	± 1% of measurement range ± 5% of measured value <sup>1, 2</sup>
Response time (T <sub>1/e</sub> ) CO <sub>2</sub>	< 3 min. diffusion time
Pressure Dependence	+1,6% reading per kPa deviation from normal pressure, 100kPa
Maintenance push buttons	Push button menus are available for configuration of outputs e.g. set points
Accuracy Temp	±1°C
Operation Temperature Range	0–50°C
Operation Humidity Range	0–85 %RH (non-condensing)
Operating environment	Residential, commercial <sup>3</sup>
Storage temperature	-40–70°C (display models: -20–50°C)
Dimensions wall mounted	120 x 82 x 30mm
Dimensions duct mounted	152 x 85 x 47mm (Probe length: 245mm)
Dimensions industrial housing	152 x 85 x 47mm
Power supply	24VDC or 24VAC (50–60Hz) ± 20%, half-wave rectifier input
Power consumption	< 3 W average
Life expectancy	>15 years <sup>3, 4</sup>
Yearly drift	< +-150ppm @1000ppm <sup>5</sup> < +-100ppm @0ppm <sup>5</sup> (can't define amount of drift during power-off)"
Serial communication	UART (Senseair protocol standard)
Maintenance	No maintenance required as Auto Background Calibration, ABC, is used. <sup>2, 3</sup>

Table I: Key technical specification for the aSENSE VAV

- Note 1: Accuracy is specified over operating temperature range. Specification is referenced to certified calibration mixtures. Uncertainty of calibration gas mixtures (+-2% currently) is to be added to the specified accuracy for absolute measurements.
- Note 2: In normal IAQ applications, accuracy is defined after minimum three (3) ABC periods of continuous operation with ABC.
- Note 3: This device generation of heat (self-heating due to power consumption) does not influence/violate temperature accuracy specification of this device, as long as CO<sub>2</sub> measurement (lamp blink) interval is ≥ 15s.
- Note 4: Repeatability is included. Uncertainty of calibration gases (+-2% currently) is added to the specified accuracy.
- Note 5: Yearly drift of unpowered sensor is not defined.

## Terminals and outputs description



Cable connections	Descriptions and ratings
<b>Power supply</b>	
1 	Positive pole of DC power supply is connected to +~. Sensor performs half wave rectification of supplied AC voltage. Power supply lines are protected by varistor from voltage spikes and over voltage. A fuse and a diode protect the electronics. Nominal specification: 24VDC, 24VAC +-20%, 50-60Hz Absolute minimum to maximum ratings 16.5 to 40VDC
2 	Connected to sensor's ground. Negative pole connection for DC power supply
5 M	Signal ground protected by PTC fuse
<b>Outputs for aSENSE VAV</b>	
3 Out(1)	Factory setting is maximum function, 0-10VDC for ( 600-900ppm CO <sub>2</sub> , 18-17°C ( 23-24°C, 23-25°C ))
4 Out(2)	Factory setting is linear output, 0-10VDC for 600-900ppm CO <sub>2</sub>
6,7 Out(3)	Isolated N.O. relay, 1mA/5V up to 1A/50VAC/24VDC.
8 Out(3)	0-10 VDC or Open collector In open collector mode max 0.5A/55VDC (halfwave rectifier for AC) Factory setting is 0-10V, PWM, 18-20 °C, Inverted input
<b>Indicators</b>	
Yellow status LED	OFF = OK, Lit = Fault. Flashes when a successful push has been done in the push button menu.
Red status LED	Lit when the relay is closed
LCD	LCD is dedicated to represent measured values and status of the sensor.
<b>Jumpers</b>	
Jumper for selection of P-band cool range	Jumper in top position provides 1°C as P-band cool range as default Jumper in lower position provides 2°C as P-band cool range as default
Out(1)	Jumper in left position gives mA output Jumper in right position gives V output, default
Out(2)	Jumper in left position gives mA output Jumper in right position gives V output, default
Out(4)	Jumper in left position gives open collector output Jumper in right position gives V output, default
<b>Serial Communication</b>	
UART (TxD, RxD)	Available from JP3. 5V CMOS logical levels, Senseair communication protocol. Logical levels corresponds 5V powered logics.  Protection 56R resistors are added on RxD and TxD lines RxD line is configured as digital input. Input high level is 2.1V min Input low level is 0.8V max TxD line is configured as digital output. Output high level is 4.0V Output low level is 0.75V max  RxD input is pulled up to DVCC = 5V by 56kΩ TxD output is pulled up to DVCC = 5V by 56kΩ

Table II: Cable connections of the aSENSE VAV.

## General PCB overview

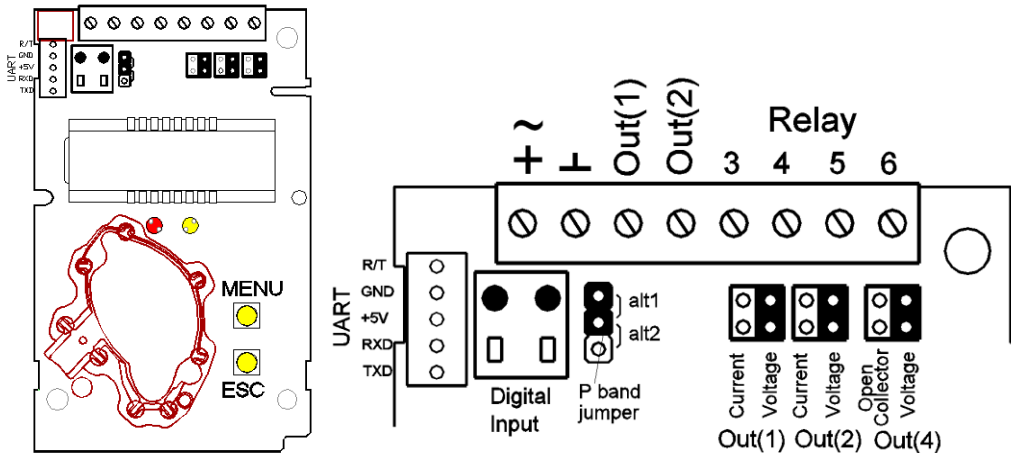


Figure 1 The aSENSE VAV PCB with jumpers and terminal area enlarged at right

Set point values of temperature (air cooling and heating) and air quality (CO<sub>2</sub>) can be adjusted individually by the unit's *maintenance push buttons*. When a set point value is changed the control curves of that parameter are parallel displaced! Out(1) controls both air quality and temperature but temperature overrules so if the temperature sinks below the LIMIT value the air supply is cut down. Two different gain alternatives can be used in the temperature/cooling feedback loop. In *alternative 1* the P-band is 1 degree and in *alternative 2* the P-band is 2 degrees. Temperature compensation of the demand control is done for temperatures below LIMIT value (see figure 2).

The standard configuration of aSENSE VAV, with its settings, is typical in many Variable Air Volume (VAV) applications. Even other control parameters can be programmed from the UIP software. There are a number of different regulator blocks available:

6 programmable *P-bands* (linear functions) with associated set points, 2 additional general purpose *P-bands*, plus 1 timer function regulator controlled by the DI1-terminal are available. In addition, the different regulator outputs may be mixed together using 3 multiplexer (4:1) blocks. To each of the 4 outputs 4 of the available functions can be addressed so that the sum, or the largest value, is transformed to an output signal. The Out(1) and Out(2) outputs can be limited within defined MIN and MAX values. These MIN and MAX values can be set/updated from the push button menu under operation.

## Push Button Operation for aSENSE VAV

This sensor has two push buttons, MENU and ESC, located on the front panel behind the flip-down lid. The YELLOW LED will acknowledge a successful push by a short flash. Wait until the LED is turned off before next push. The push button MENU is available for selection of display value or maintenance commands, whereas ESC is available to escape back from a selected level.



Figure 2 The sensor with push buttons



Figure 3 The push button MENU is pushed



Figure 4 The push button ESC is pushed



Figure 5 The ENTER command is done by pushing buttons MENU and ESC at the same time for about 14s.

## Display modes

In DISPLAY MODE the *DEFAULT* operation is that the sensor alternates between *temperature and carbon dioxide readings* presentation. The push button MENU(+) is used to select the indicated value on the display to be *the error code or the set points of temperature and CO<sub>2</sub>*. The display will always return to the Default display mode after power up. If a *permanent change* of default values is requested the PC software is to be used.

Function Line	Display	Time limit	Function description
0	Temperature / CO <sub>2</sub>	no	DEFAULT - Normal operation
1	Exxx	yes	Error code. If no error has been detected the code E0 is shown. The error code is reset with Entr(+/-).
2	Present temperature- and CO <sub>2</sub> set points	no	Toggle between display of temperature and CO <sub>2</sub> set point with MENU(+).

Table III. On the display without entering the maintenance menu

## Maintenance level

A number of execution options are available from the MAINTENANCE MENU (see Table IV). This level is accessed only from the display mode in the **set points of temperature and CO<sub>2</sub>** selection. A two buttons push and an access code restrict access, intended for competent trained service personnel only. The Entr(+/-) command is done by PUSHING MENU AND ESC AT THE SAME TIME (hold down for about 15 seconds). The access code has eight binary digits; one press at MENU(+) equals 1 and one press at ESC(-) equals 0. The code value can be changed for your personal choice from the software UIP 4.3. The menu diagram in detail is shown in the appendix.

Always use the ESC button to return to the DEFAULT mode. Several pushes of the ESC button may be needed to return to the DEFAULT mode. The **Entr(+/-)** push (MENU & ESC) eventually leads to execution of functions, which causes temporary or permanently change of any parameter, that affects the system outputs!

Function Line	Display	Time limit	Function description
3	ECxx	yes	Access code to the <b>service menu</b> . The default value of the code is 255 (=11111111, that is eight presses on MENU(+)). Press down MENU(+) and let it scroll until it stops. The last two digits of the code are shown. Then ENTER to accept the selected code.
4a	SPT	yes	For setting the <b>temperature set point</b> .
4b	The present temperature set point	yes	For <b>increase / decrease</b> of the <b>temperature set point</b> . The set point is increased by stepping with MENU(+) button. Decreasing is done by stepping with the ESC(-) button.
5a	SPc	yes	For setting the <b>set point of the CO<sub>2</sub> concentration</b>
5b	The present CO <sub>2</sub> set point	yes	For <b>increase / decrease</b> of the <b>CO<sub>2</sub>-concentration set point</b> . The set point is increased by stepping with MENU(+) button. Decreasing is done by stepping with the ESC(-) button.
6a	AOUt	yes	First step of adjusting the analogue outputs MAX and MIN values
6b	An xx	no	Select analogue output by stepping with MENU(+) button.
6c1	SetL	no	Leads to adjustment of the MIN value.
6d1	The present MIN value in % of FS	no	Increase the MIN value by stepping with the MENU(+) button. Decrease by stepping with the ESC(-) button. The output is set to the MIN value and can be checked with a multimeter.
6e1	Sure	no	The adjustment is saved by pressing Entr(+/-). Press ESC to return without saving.
6c2	SetH	no	Leads to adjustment of the MAX value
6d2	The present MAX value in % of FS	no	Increase MAX value by stepping with the MENU(+) button. Decrease by stepping with the ESC(-) button. The output is set to the MAX value and can be checked with a multimeter.
6e2	Sure	no	The adjustment is saved by pressing Entr(+/-). Press ESC to return without saving.
7	CALb	yes	<b>Background calibration = CO<sub>2</sub>-sensor calibration with fresh air.</b> An easy way to correct the zero point error. The sensor needs fresh air (380-420 ppm CO <sub>2</sub> ). The calibration must be confirmed by pressing Entr(+/-).
7a	Sure	yes	Confirm that a background calibration shall be done.
8	CAL	yes	<b>Zero point calibration</b> of the CO <sub>2</sub> sensor. The sensor needs zero gas. See the zero point calibration instruction. The calibration must be confirmed by pressing Entr(+/-).
8a	Sure	yes	Confirm that a zero point calibration shall be done.

Table IV: Maintenance functions available on aSENSE VAV to set output limits. Time limit refers to an internal time-out that returns the LCD and maintenance function back to normal. ENTER is a simultaneous pressing on MENU and ESC.

**NOTE!** If a power failure happens when the sensor has Out(1)...4 locked to min/max limits, then the sensor will have this output locked when the power returns. It is necessary to enter this menu item and release the output manually!

## Calibration

The aSENSE VAV are maintenance free in normal environments thanks to the built-in self-correcting **ABC algorithm** (Automatic Baseline Correction). This algorithm constantly keeps track of the sensor's lowest reading over a 7.5 days interval and slowly corrects for any long-term drift detected as compared to the expected fresh air value of 400ppm CO<sub>2</sub>.

Rough handling and transportation might, however, 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 however limited to about 30-50ppm/week.

A Back-ground calibration is an easy way to correct a sensor's zero point. The sensor needs fresh air (380-420 ppm CO<sub>2</sub>).

A zero calibration can be performed by use of pure nitrogen or air that has passed through a chemical absorber. When a zero calibration shall be executed a plastic tube with 2.2 mm outer diameter and 0.8 mm inner diameter shall be inserted in marked holes of the sensor. Plastic tubing is connected to the tube. The gas flow should be between 0.3 and 1.0 l/min.

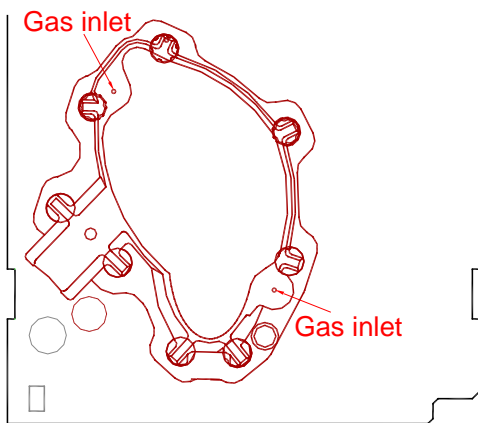


Figure 6 Part of the PCB with holes for gas inlets marked

## Self-diagnostics

The system contains complete self-diagnostic procedures. A full system test is executed automatically every time the power is turned on. For aSENSE VAV the internal voltage regulators and outputs are checked. 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 error codes are available by connecting a PC with a special RS232 cable connected to the UART port slide connector. The error codes are shown in the software UIP (version 4.3 or later). *Warm up* and *Out of Range* are the only bits that are reset automatically after return to normal state. All other error bits have to be reset manually after return to normal state – either by pushing MENU and ESC buttons simultaneously for =Entr(+/-) or by power off and restart.

By pushing the push button "MENU" the error code *number Exxx* is shown on the LCD. Descriptions of the different codes are listed below.

**Yellow LED flashes:** error has been detected.

**Yellow LED lits:** a fatal error has been detected.



## Error code and action plan

Bit #	Error code	Error description	Suggested action
0	N/A	Fatal Error	Try to restart sensor by power OFF/ON. Contact local distributor
1	2	Reserved	
2	4	<b>Algorithm Error.</b> Indicate wrong EEPROM configuration.	Try to restart sensor by power OFF/ON. Check detailed settings and configuration with UIP software version 4.3 and higher. Contact local distributor.
3	8	<b>Output Error</b> Detected errors during output signals calculation and generation.	Check connections and loads of outputs. Check detailed status of outputs with UIP software version 4.3 and higher.
4	16	<b>Self-Diagnostic Error.</b> Algorithm timeout	Check detailed self-diagnostic status with UIP software version 4.3 and higher. Contact local distributor
5	32	<b>Out of Range Error</b> Accompanies most of other errors.  Resets automatically after source of error disappearance.	Try sensor in fresh air. Check connections of temperature and relative humidity probe. Check detailed status of measurements with UIP software version 4.3 and higher.  <i>See Note 1!</i>
6	64	<b>Memory Error</b> Non-fatal error during memory operations.	Check detailed settings and configuration with UIP software version 4.3 and higher.
7	128	<b>Warm-Up state</b> Is always set after power up or power failure. Resets after restart sequence.	If it doesn't disappear in half a minute, check power stability.

Table V: Error codes

**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, the temperature sensor can be defect or the connections to it are broken.

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

**NOTE!** The sensor accuracy is defined at continuous operation (at least three (3) ABC periods after installation)

## Drawings

Refer to mechanical drawing for detailed information regarding dimensions and tolerances.

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