CO_2 Engine™ K30

Sensor module and OEM platform

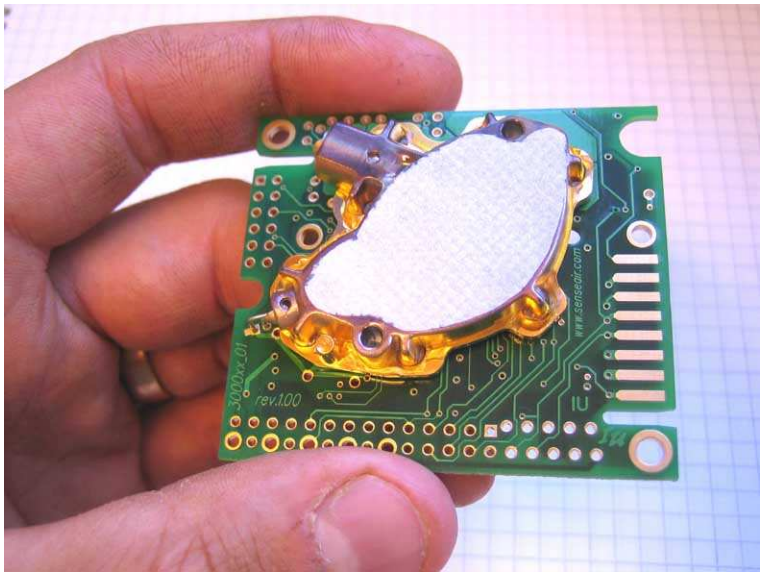


Figure 1. CO_2Engine™ K30

General

- The **K30** sensor platform CO_2Engine™ K30 can be customized for a variety of sensing and control applications. This platform is designed to be an OEM module for built-in applications in a host apparatus, and hence should be optimized for its tasks during a dialog between SenseAir and the OEM customer. This document is to be considered as the starting point for such a dialog.
- This document describes an appearance of the K30 sensor platform named CO_2Engine™ K30-STA.

I/O notations used in this document, terminal positions and some important **K30** platform PCB dimensions are described at the next two pages.

Terminal descriptions

The table below specifies what terminals and I/O options are available in the general **K30** platform *(see also the layout picture Fig. 2)*. Please note, however, that in the CO_2Engine™ K30-STA default configuration, only OUT1, OUT2, OUT3, OUT4, Din1, Din2 and Status have any pre-programmed functions. These are described in the chapter *"Default Configuration"*.

Functional group	Descriptions and ratings
Power supply	
G+ referred to G0:	Absolute maximum ratings 4.5 to 14V, stabilized to within 10% 4.5 to 9V preferred operating range. **Unprotected against reverse connection!**
Serial Communication	
UART (TxD, RxD)	CMOS, ModBus communication protocol. Logical levels corresponds 3.3V powered logics. Refer *"ModBus on CO2 Engine K30 "* for electrical specification.
Outputs	
OUT1	Buffered linear output 0..4 or 1..4VDC or 0..10V or 2..10V, depending on specified power supply and sensor configuration. R_{OUT} < 100 Ω, R_{LOAD} > 5 kΩ **Load to ground only**! Resolution 10mV (8.5 bits in the range 0..4V).
OUT2	Buffered linear output 0..4 or 1..4VDC or 0..5V or 1..5V, depending on specified power supply and sensor configuration. R_{OUT} < 100 Ω, R_{LOAD} > 5 kΩ **Load to ground only!** Resolution 5mV Can be used as alternative for OUT1, or for a second data channel, or in an independent linear control loop, such as a housing temperature stabilization
OUT3	CMOS **unprotected**. Digital (High/Low) output. High Output level in the range 2.3V min to DVDD = 3.3V. (1 mA source) Low output level 0.75V max (4 mA sink) Can be used for gas alarm indication, or for status indication etc.
OUT4	CMOS **unprotected.** Digital (High/Low) output. High Output level in the range 2.3V min to DVDD = 3.3V. (1 mA source) Low output level 0.75V max (4 mA sink) Can be used for gas alarm indication, or for status indication etc.
Status	CMOS **unprotected.** High Output level in the range 2.3V min to DVDD = 3.3V. (1 mA source) Low output level 0.75V max (4 mA sink)
Inputs	
Din0, Din1, Din2, Din3, Din4	Digital switch inputs, pull-up 120k to DVCC 3.3V. Driving it Low or connecting to ground G0 activates input. Pull-up resistance is decreased to 4..10k during read of input or jumper. Advantages are lower consumption most of the time the input/jumper is kept low and larger current for jumpers read in order to provide cleaning of the contact. Can be used to initiate calibration or to switch output range or to force output to predefined state. All depends on customer needs.

Optional jumper field

Din0, Din1, Din2, Din3, Din4	Digital switch inputs, pull-up 120k to DVCC 3.3V. Connecting to ground G0 activates input. Pull-up resistance is decreased to 4..10k during read of input or jumper. Advantages are lower consumption most of the time the input/jumper is kept low and larger current for jumpers read in order to provide cleaning current. They are the same as inputs on IDC connector. Can be used to initiate calibration or to switch output range or to force output to predefined state. All depends on customer needs.

I^2C extension.

Contact SenseAir for information	Pull-up of SDA and SCL lines to 3.3V.

Table I. I/O notations used in this document for the K30 platform with some descriptions and ratings. Please, beware of ***the red colored texts that pinpoint important features*** *for the system integration!*

General PCB overview

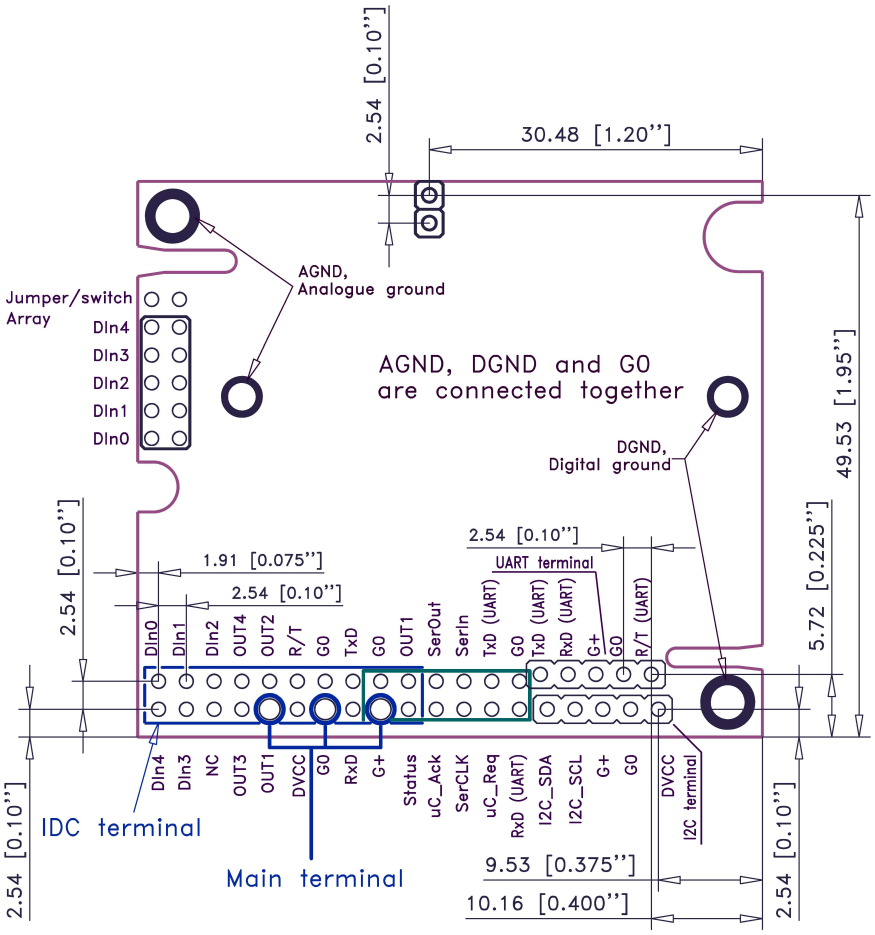


Figure 2 . CO_2Engine™ K30 I/O notations, terminal positions and some important dimensions for mounting the K30 platform PCB into a host system (Top view). The blue filled pins are defined by default.

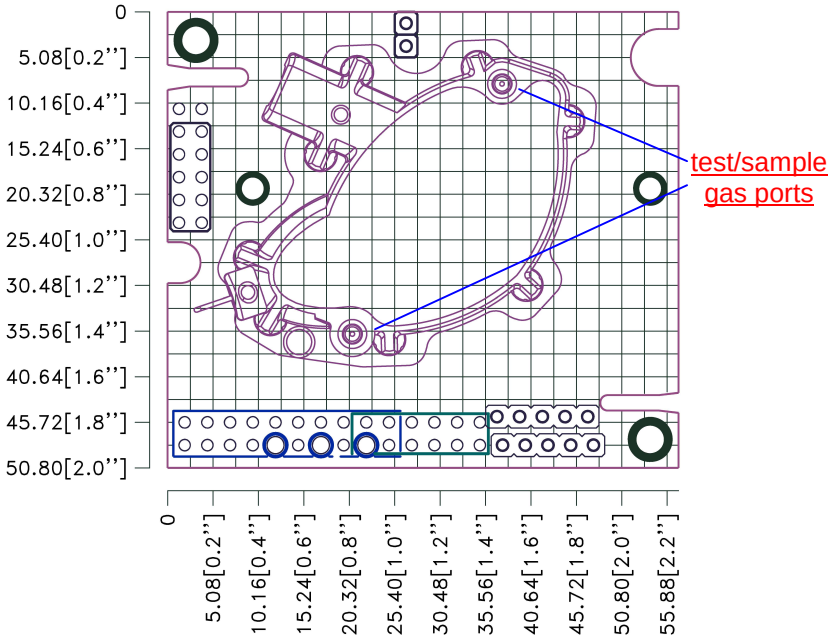


Figure 3 . CO_2Engine™ K30 OBA position.

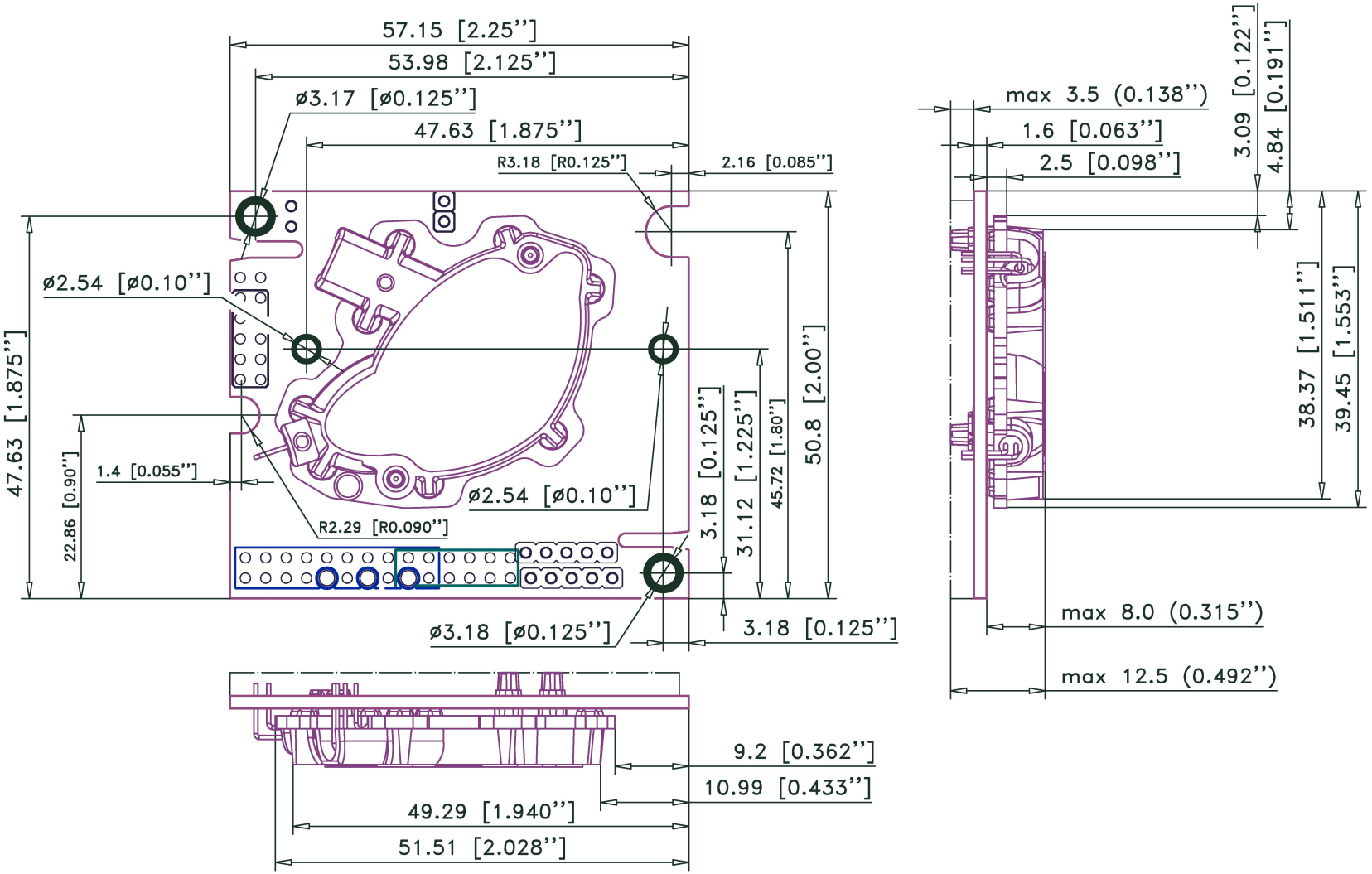


Figure 4 . CO_2Engine™ K30 mechanical drawing.

Installation

The modules are factory calibrated and ready for use directly after power up. There are several alternative ways to connect the CO_2Engine™ K30 to a host system (see also figure 2):

Do not use edge connector for connection to the host system without discussion with SenseAir!

1. Using "UART connector", including terminals for power supply (G+ and G0), UART (TxD, RxD).

2. Using the 3 pins **main terminal**. Available signals are power supply (G+ and G0) and the buffered analogue output (OUT1). A variety of user selections exist for this option regarding standard 5.08 mm pitch components and mounting alternatives (top/bottom).

3. Using 20 pin connector strips, or **IDC connector**, most of the system information is reached.

Host integration considerations and EMI shielding

If an IDC connector is being used to connect the K30 module to a host PCB, this connector can in some situations be used as the only fixture. If instead fixing the K30 PCB using mechanical poles and screws, no more than 2 positions should be considered. This is because the PCB should not be exposed to any mechanical stress, and it is small and lightweight enough for just 2 attachment points.

To provide means for attachments, there are 4 possible screw holes available, all of them having a collar that is electrically connected to ground (G0). These connections are, however, not totally equivalent:

- The two screw points in the upper left corner (having the IDC and edge connectors faced downwards, as in Figure 2) are connected to the *analogue* ground. They are the preferred choice for connection to some EMI shield, if so is required. This is normally necessary only if the application is such that large EMFs are foreseen. If this option is being used, precaution must be taken so as to exclude any power supply currents! Sensor reading instability is an indication of the need for shielding, or of improper enclosure system groundings.

- The two screw points in the right bottom corner are connected to the *digital* ground. Connection to some EMI housing shield is less effective when this option is used, but on the other hand the sensor may be powered via these connections.

Note 1: To avoid ground loops, one should avoid connecting the analogue and digital grounds externally! They are connected internally on the K30 PCB.

Note 2: The terminals are not protected against reverse voltages and current spikes! Proper ESD protection is required during handling, as well as by the host interface design.

Default functions /configurations

Outputs

The basic CO_2Engine™ K30-STA configuration is a simple analogue output sensor transmitter signal directed to OUT1 and OUT2. Via the edge connector serial communication terminal, the CO_2 readings are available to an even higher precision (Modbus protocol), together with additional system information such as sensor status, analogue outputs, and other variables.

Terminals	Output	Correspondence
OUT1	0,0…4,0 VDC	0…2000 ppm CO_2
OUT2	1,0…5,0 VDC	0…2000 ppm CO_2

Table II. Default analogue output configuration for CO_2Engine™ K30-STA

The basic CO_2Engine™ K30-STA configuration provides digital outputs to indicate if CO_2 concentration exceeds alarm threshold.

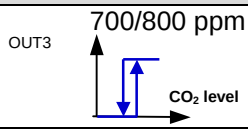
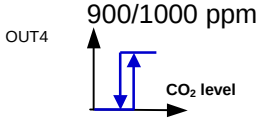
Terminals	Output	Correspondence
OUT3	Logical levels: Low <0.75V High>2.3V and <3.3V	
OUT4	Logical levels: Low <0.75V High>2.3V and <3.3V	

Table II. Default digital output configuration for CO_2Engine™ K30-STA

Calibration

The default sensor OEM unit is 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 400 ppm CO_2.

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 ppm/week. For post calibration convenience, in the event that one cannot wait for the ABC algorithm to cure any calibration offset, two switch inputs Din1 and Din2 are defined for the operator to select one out of two prepared calibration codes. If Din1 is shorted to ground, for a minimum time of 8 seconds, the internal calibration code **bCAL** *(background calibration)* is executed, in which case it is assumed that the sensor is operating in a fresh air environment (400 ppm CO_2). If Din2 is

shorted instead, for a minimum time of 8 seconds, the alternative operation code **CAL** *(zero calibration)* is executed in which case the sensor must be purged by some gas mixture free from CO_2 (i.e. Nitrogen or Soda Lime CO_2 scrubbed air). If unsuccessful, please wait at least 10 seconds before repeating the procedure again. Make sure that the sensor environment is steady and calm! Refer calibration procedure description on the next page.

Input Switch Terminal *(normally open)*	**Default function** *(when closed for minimum 8 seconds)*
Din1	**bCAL** (background calibration) assuming 400 ppm CO_2 sensor exposure
Din2	**CAL** (zero calibration) assuming 0 ppm CO_2 sensor exposure

Table III. Switch input default configurations for CO₂Engine™ K30

Calibration procedure

The zero calibration procedure is as follow:

1. Connect the sensor on top with a tube (soft tubing 2x4 mm) and a nipple (nylon tubing 30x0.8x2.2 mm), see Figure 4 below. There are 2 alternative positions for nipple attachment.
2. Let a gas mixture flow into the sensor through the applied tube. The flow shall be in the range of 0.3 – 1.0 liter/minute during 3 minutes. Keep the gas mixture flowing during the whole procedure.
3. Short circuit the Din2 for a minimum time of 8 seconds.
4. Verify the zero calibration. The meter shall show 0 ppm CO2.
5. If zero calibration is not executed (sensor detected unstable gas concentration) wait 10 sec and repeat steps 3 and 4 again. Do not breath on the sensor!

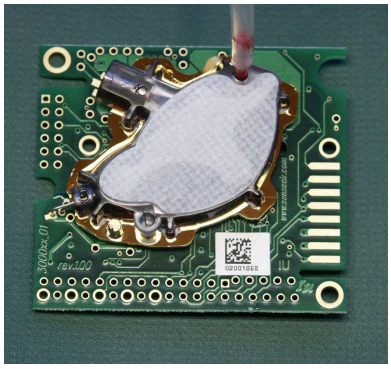


Figure 4. K30 with connected tube

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. If this byte is not zero, the logic output terminal **Status** will be put into Low level state. The full error codes are available from the UART port or via I^2C communication. *Offset regulation error* 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 after return to normal by UART overwrite, or by power off/on.

Output Terminal	Default function
Status	**High level** = OK ; **Low level** = Fault

Table IV. Default Logic output configured for CO_2Engine™ K30

Error code and action plan (error code can be read via one of communication channels)

Bit #	Error code	Error description	Suggested action
0	1	**Fatal Error**	Try to restart sensor by power OFF/ON. Contact local distributor.
1	2	**Offset regulation error**	Try to restart sensor by power OFF/ON. Contact local distributor.
2	4	**Algorithm Error**. Indicate wrong EEPROM configuration.	Try to restart sensor by power OFF/ON. Check detailed settings and configuration with software tools. Contact local distributor.
3	8	**Output Error** Detected errors during output signals calculation and generation.	Check connections and loads of outputs. Check detailed status of outputs with software tools.
4	16	**Self-Diagnostic Error**. May indicate the need of zero calibration or sensor replacement.	Check detailed self-diagnostic status with software tools. Contact local distributor.
5	32	**Out Of Range Error** Accompanies most of other errors. Can also indicate overload or failures of sensors and inputs. Resets automatically after source of error disappearance.	Check connections of temperature and relative humidity probe (if mounted). Try sensor in fresh air. Perform CO_2 background calibration. Check detailed status of measurements with software tools. *See Note 1!*
6	64	**Memory Error** Error during memory operations.	Check detailed settings and configuration with software tools.
7	128	**Reserved**	

Note 1. *Any probe is out of range. Occurs, for instance, during over-exposure of CO_2 sensor, in which case the error code will automatically reset when the measurement values return to normal. Could also indicate the need of zero point calibration. If the CO_2 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*.

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

Maintenance

The ***CO₂Engine™ K30*** is basically maintenance free in normal environments thanks to the built-in self-correcting *ABC* algorithm. Discuss your application with SenseAir in order to get advice for a proper calibration strategy.

When checking the sensor accuracy, PLEASE NOTE that the sensor accuracy is defined at continuous operation (at least 3 weeks after installation)!

CO_2Engine™ K30-STA - Technical specification

General Performance:

Storage Temperature Range	-30 to +70 ℃
Sensor Life Expectancy	> 15 years
Maintenance Interval [1]	no maintenance required
Self-Diagnostics	complete function check of the sensor module
Warm-up Time	≤ 1 min
Conformance with the standards	Emission: EN61000-6-3:2001 Immunity: EN61000-6-2:2001 RoHS directive 2002/95/EG
Operating Temperature Range	0 to 50 °C
Operating Humidity Range	0 to 95% RH (non-condensing)
Operating Environment	Residential, commercial, industrial spaces and Potentially dusty air ducts used in HVAC (Heating Ventilation and Air-Conditioning) systems.[4]

Electrical / Mechanical:

Power Input	4,5-14 VDC, stabilized to within 10% (external protection circuits required) [3]
Current Consumption	40 mA average < 150 mA peak current (averaged during IR lamp ON, 120 msec) < 300 mA peak power (during IR lamp start-up, the first 50 msec)
Electrical Connections [4]	terminals not mounted (G+, G0, OUT1, OUT2, Din1, Din2, Status, TxD, RxD)
Dimensions	5,1 x 5,7 x 1,4 cm (Length x Width x approximate Height)

CO_2 Measurement: [4]

Sensing Method	non-dispersive infrared (NDIR) waveguide technology with ABC automatic background calibration algorithm
Sampling Method	diffusion
Response Time ($T_{1/e}$)	20 sec diffusion time
Measurement Range	0 - 5 000 $ppm_{vol.}$
Sensitivity	± 20 ppm ± 1 % of measured value
Accuracy [1]	± 30 ppm ± 5 % of measured value
Pressure Dependence	+ 1.6 % reading per kPa deviation from normal pressure, 100 kPa
On-board calibration support	Din1 switch input to trigger Background Calibration @ 400 ppm CO_2 Din2 switch input to trigger Zero Calibration @ 0 ppm CO_2

Linear Signal Outputs: [4,5]

D/A Conversion Accuracy		± 2 % of reading ± 20 mV
OUT1	D/A Resolution	10 mV
	Linear Conversion Range	0 - 4 VDC for 0 - 2 000 $ppm_{vol.}$
	Electrical Characteristics	R_{OUT} < 100 Ω, R_{LOAD} > 5 kΩ , Power input > 4,5 V [6]
OUT2	D/A Resolution	5 mV
	Linear Conversion Range	1 - 5 VDC for 0 - 2 000 $ppm_{vol.}$
	Electrical Characteristics	R_{OUT} < 100 Ω, R_{LOAD} > 5 kΩ , Power input > 5,5 V [6]

Digital Outputs: [4]

Electrical Characteristics	High Output level in the range 2.3V min to DVDD = 3.3V. (1 mA source)
	Low output level 0.75V max (4 mA sink). Protection 56R resistor in series.
Function	High level at *CO_2 High*
OUT3, CO_2 High Alarm /Reset Level	800/700 ppm
OUT4, CO_2 High Alarm /Reset Level	1000/900 ppm

UART Serial com port [4]

Protocol	MODBUS open protocol, refer specification and registers definitions
Hardware interface	CMOS UART with RxD, TxD
Baud Rate	9600

Note 1: In normal IAQ applications. Accuracy is defined after minimum 3 weeks of continuous operation. However, some industrial applications do require maintenance. Please, contact SenseAir for further information!
Note 2: SO_2 enriched environments are excluded.
Note 3: Notice that absolute maximum rating is 14V, so that sensor can be used with 12V+-10% supply
Note 4: Different options exist and can be customized depending on the application. Please, contact SenseAir for further information!
Note 5: During power up, OUT1 and OUT2 are defined to be low. Exact value depends on many factors including temperature.
Note 6: For the buffered outputs OUT1 and OUT2 the maximum output voltage range equals power voltage input minus 0,5 V

WARRANTY and Limitation of Liability

1. SenseAir warrants that for a period of twenty four (24) months following receipt by Buyer the Product supplied by SenseAir to Buyer will be, under normal use and care, free from defects in workmanship or material and to be in material conformity with SenseAir's specifications. Units returned to SenseAir for warranty repairs shall be shipped to SenseAir**,** at Buyer's expense, according to SenseAir's instruction. Within ninety (90) days of the receipt of product, SenseAir shall replace or repair such units and shall ship them to Buyer's designated return destination freight pre paid.

2. Warranty Limitations. This warranty does not extend to any unit that has been subject to misuse, neglect or accident; that has been damaged by causes external to the unit; that has been used in violation of SenseAir's instructions; that has been affixed to any non-standard Accessory attachment; or that has been modified, disassembled, or reassembled by anyone other than SenseAir.

3. The retailer is not responsible for any consequential loss or damages, which may occur by reason of purchase and use of this product. The warranty is, in any event, strictly limited to the replacement/repair of the product

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