

## Product Description

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# *CO<sub>2</sub> Engine™ .ICB*

*Sensor module for bio applications*

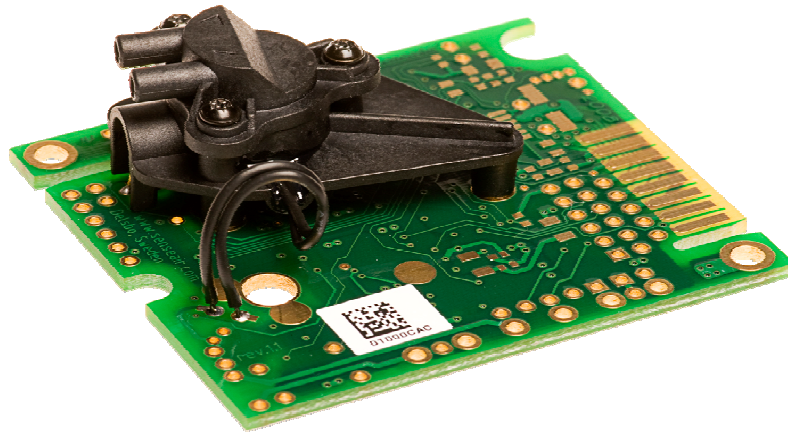


Figure 1. **CO<sub>2</sub>Engine™ ICB** (tube IN/OUT model)

### General

- **CO<sub>2</sub> Engine™ ICB** is targeted on bio applications with required measurement range 0 to up to 30%<sub>vol</sub> CO<sub>2</sub>. This document contains description of default appearance of **CO<sub>2</sub> Engine™ ICB**.
- **CO<sub>2</sub> Engine™ ICB** is built on the **CO<sub>2</sub> Engine™ K33 platform**. This platform is designed to be a low power OEM module for built-in applications in a host apparatus or/and as a stand alone CO<sub>2</sub> transmitter/switch module, 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. One can find extra ideas on connection and use of **CO<sub>2</sub> Engine™ K33 platform** in platform description.
- **CO<sub>2</sub> Engine™ ICB** has the same dimension and attachment points as K30 platform based sensors.

## Connection to host system alternatives

(See electrical specifications in the table “Terminal description” below)

### Connection alternative A.

**CO<sub>2</sub> Engine™ ICB** is built in into the customer’s system by connection via JP5. I<sup>2</sup>C communication is used to read measured data from the sensor. Detailed description of I<sup>2</sup>C communication with useful examples and troubleshooting can be found in “I<sup>2</sup>C comm guide 2\_14.pdf”

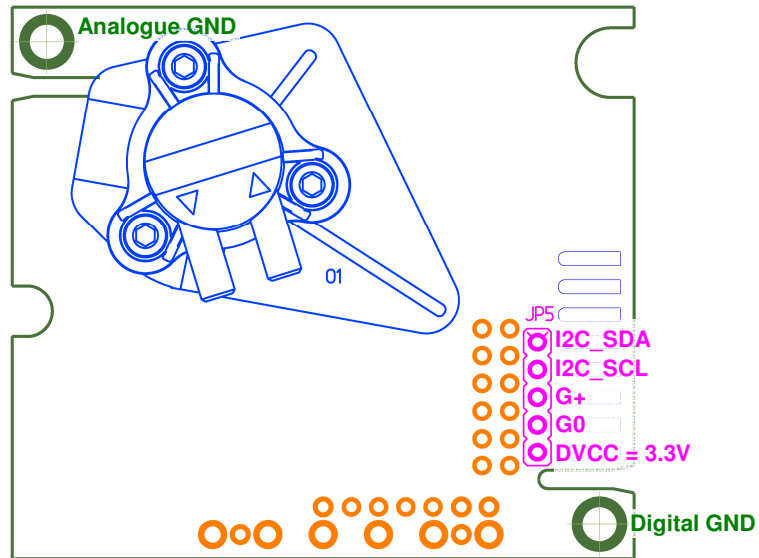


Figure 2. **CO<sub>2</sub> Engine™ ICB** Possible connection terminals for reading via I<sup>2</sup>C.

Note: Both Digital GND and Analog GND are connected to G0 internally.

**Connection alternative B.**

**CO<sub>2</sub> Engine™ ICB** is built in into the customer’s system by connection via JP1 or some part of it. UART with Modbus protocol communication is used to read measured data from the sensor. **CO<sub>2</sub> Engine™ ICB** shares specification and Modbus register map with CO2 Engine K30 sensor family. Specification can be found in “ModBus on CO2 Engine K30 rev1\_07.pdf” and “K30 ModBus map rev1\_01.xls”

**View from component side:**

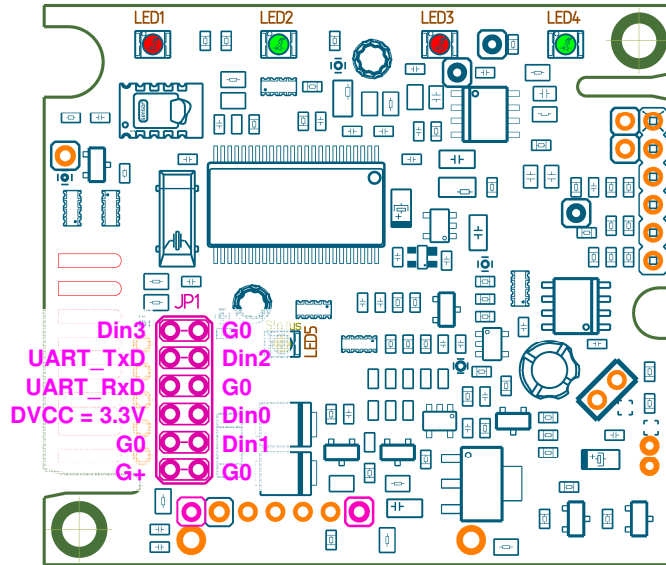


Figure 3a. **CO<sub>2</sub> Engine™ ICB** Possible connection terminals for reading via UART.

Note: LEDs are optional.

**View from OBA side:**

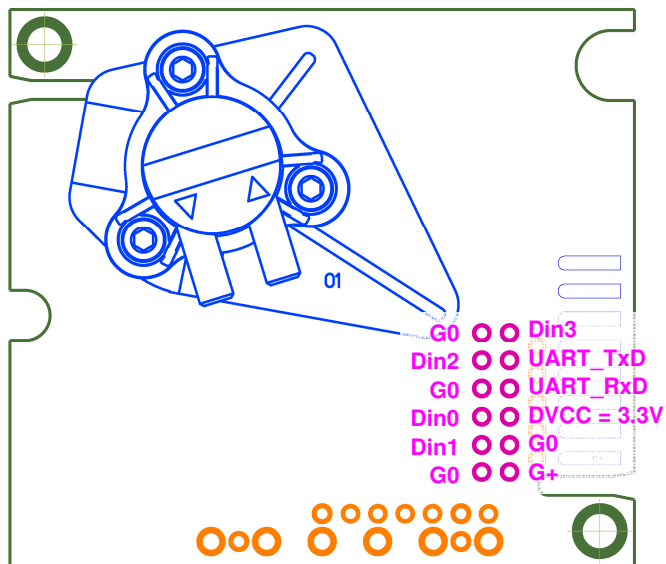


Figure 3b. **CO<sub>2</sub> Engine™ ICB** Possible connection terminals for reading via UART.

## Connection alternative C.

**CO<sub>2</sub> Engine™ ICB** is built in into the customer’s system by connection via terminals. Signal lines on these terminals are protected and long wires may be used for connection to the host system.

### 5.08 mm pitch:

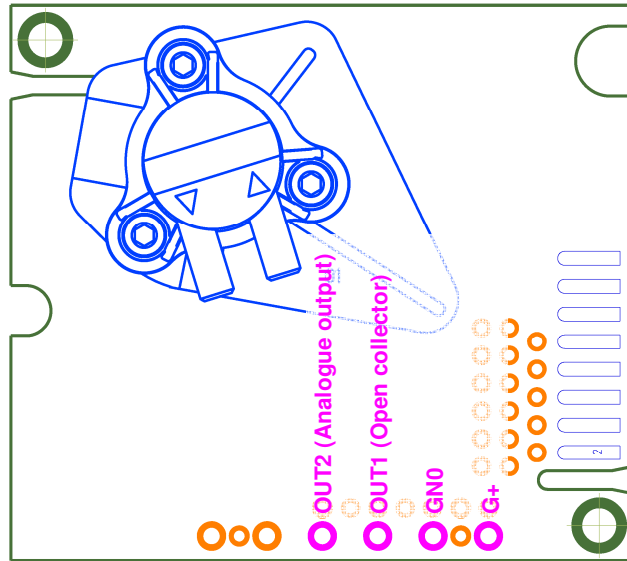


Figure 4a. **CO<sub>2</sub> Engine™ ICB** Possible connection terminals for connection by long wires.

### 2 mm pitch:

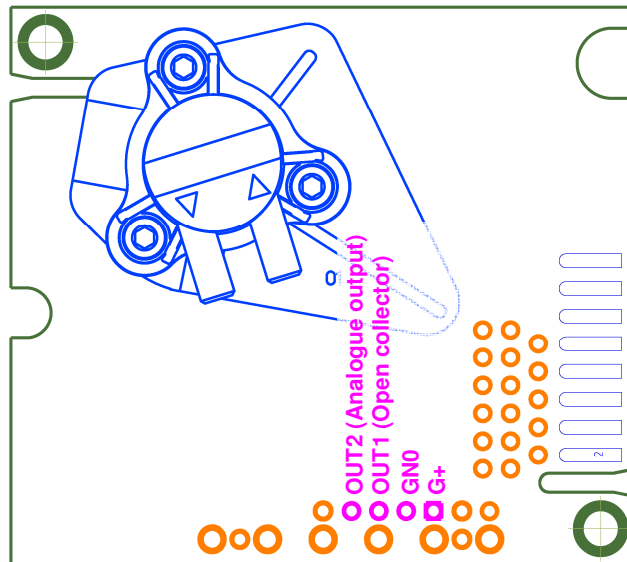


Figure 4b. **CO<sub>2</sub> Engine™ ICB** Possible connection terminals for connection by long wires.

Note: OUT1, open collector is configured to provide PWM signal, see specification below.

### Connection alternative D.

Combination of alternatives B and C. It's possible to use both UART and OUT1 at the same time. In the same way it's possible to use alternatives A and C, I2C and OUT1 at the same time.

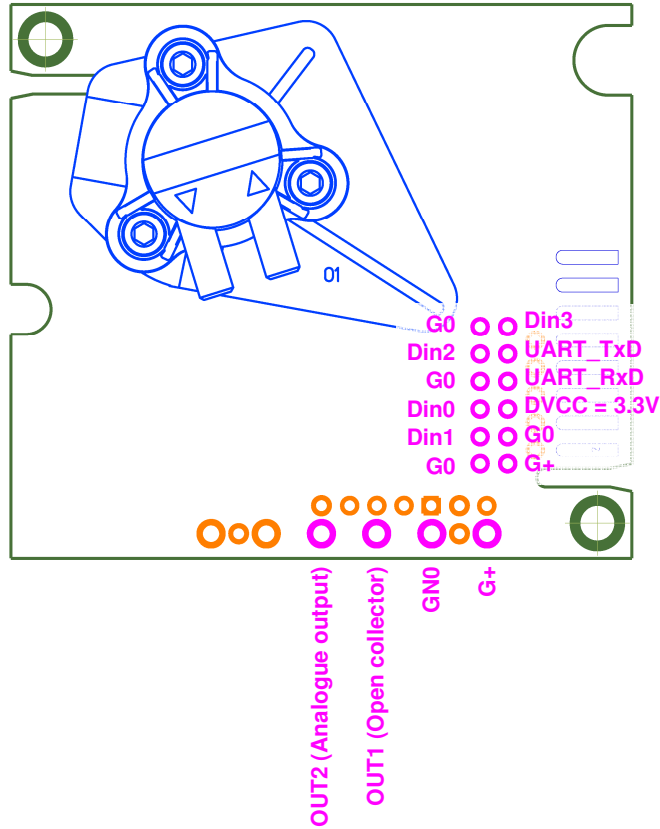


Figure 5. **CO<sub>2</sub> Engine™ ICB** Possible connection terminals for connection by long wires and UART at the same time.

## Diffusion or tube IN/OUT alternatives

**CO<sub>2</sub> Engine™ ICB** can be supplied in diffusion modification with or without O-ring.



Figure 6. **CO<sub>2</sub> Engine™ ICB** diffusion model.

**CO<sub>2</sub> Engine™ ICB** can be supplied in tube in/out modification with different orientation of tube attachment head in steps of 120 degrees.

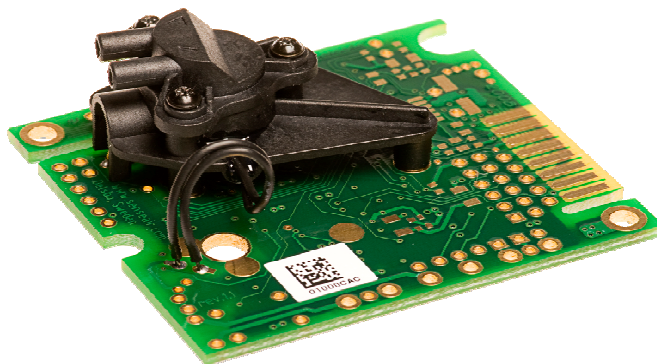


Figure 7. **CO<sub>2</sub> Engine™ ICB** tube IN/OUT model.

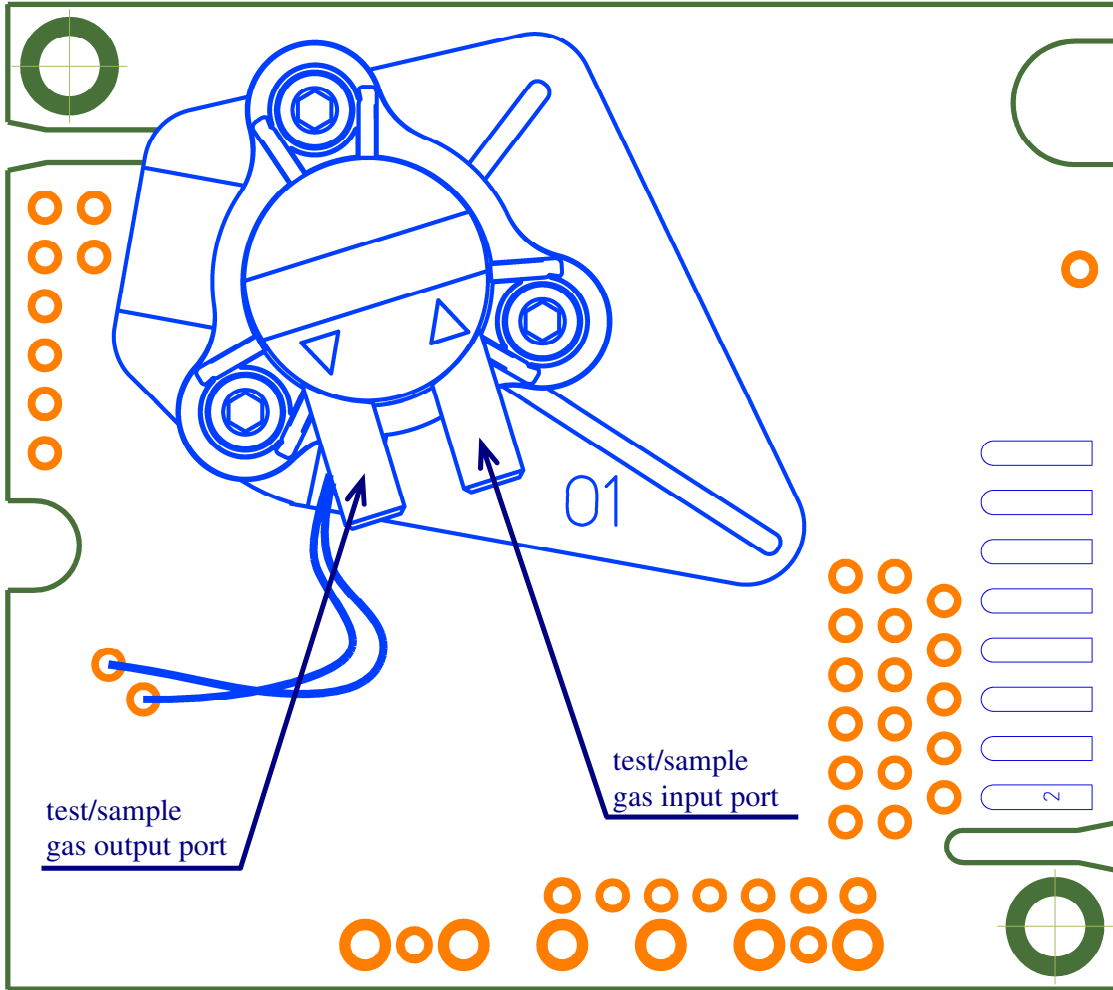


Figure 8a . **CO<sub>2</sub>Engine™ ICB** Test/sample gas ports.

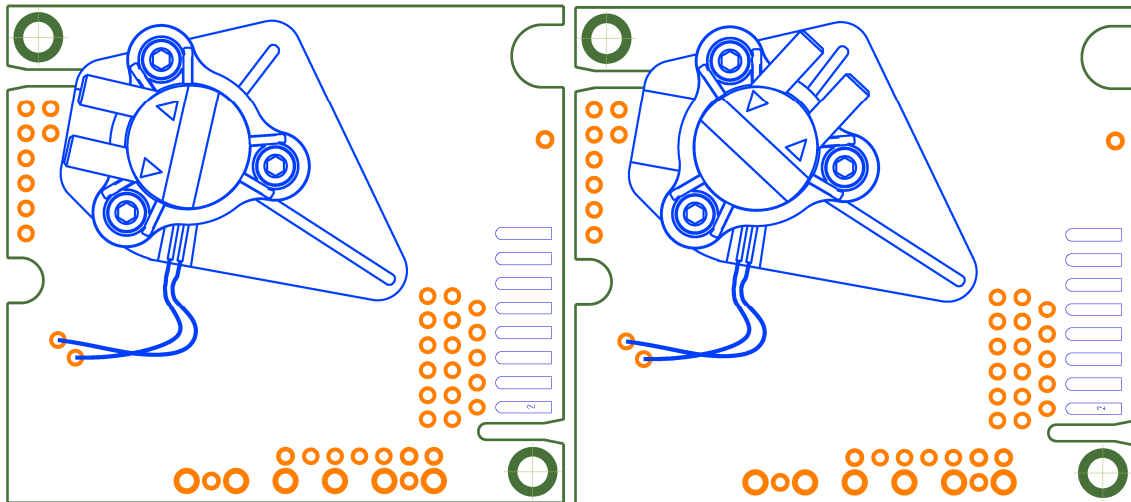


Figure 8b . **CO<sub>2</sub>Engine™ ICB** Possible test/sample gas ports installations.

## Terminal description

The table below specifies terminals and I/O options available in the general **K33** platform (*see also the alternative connection pictures above*).

Functional group	Descriptions and ratings
<b>Power supply (all connection alternatives)</b>	
G+ referred to G0	Power supply plus terminal Protected by series 3.3R resistor and zener diode Absolute maximum ratings 5 to 14V, stabilized to within 10%
G0	Power supply minus terminal Sensor's reference (ground) terminal
DVCC = 3.3V	Output from sensor's digital voltage regulator. Series resistance 10 R Available current 12mA Voltage tolerance (unloaded) +-3% max (+-0.75% typ) Output may be used to power circuit (microcontroller) in host system or to power logical level converter if master processor runs at 5V supply voltage.
<b>Communication</b>	
UART (UART_TxD, UART_RxD)	CMOS physical layer, ModBus communication protocol. (refer "ModBus on CO2 Engine K30 rev1_07.pdf" or later version for details)  UART_RxD line is configured as digital input. Input high level is 2.1V min Input low level is 0.8V max  UART_TxD line is configured as digital output. Output high level is 2.3V (assuming 3.3V DVCC) min. Output low level is 0.75V max  UART_RxD input is pulled up to DVCC = 3.3V by 56 kOhm UART_TxD output is pulled up to DVCC = 3.3V by 56 kOhm  <b>ABSOLUTE MAX RATING      G0-0.5V      .....      DVCC + 0.5V</b>
I2C extension. (I2C_SCL, I2C_SDA)	Pull-up to DVCC = 3.3V. (refer "I2C comm guide rev2_00 DRAFT.pdf" or later version for details)  <b>ABSOLUTE MAX RATING      G0-0.5V      .....      DVCC + 0.5V</b>
<b>Outputs</b>	
OUT1, OC (Open collector)	Digital output, Open collector  Series resistance 120 R Max sink current 40mA  May be configured as 1. Alarm indication output 2. PWM output, 10 (alt. 12 to 16) bit resolution. Period 1 .. 1000 msec 3. Pulse length proportional to measured CO2 value.
OUT2	Analog output 0..5V



	Buffered linear output 0..4 or 1..4VDC or 0..5V or 1..5V, depending on specified power supply and sensor configuration. $R_{OUT} < 100 \Omega$ , $R_{LOAD} > 5 k\Omega$ <b>Load to ground only!</b> Resolution 5mV
RELAY (RelayPoleNC RelayPoleCom RelayPoleNO)	RELAY It's not a standard option.  Maximum switching capability 1A/50VAC/24VDC
<b>Digital I/Os, used as Inputs in standard configuration. May be implemented as jumper field</b>	
Din0 Din1 Din2	Digital switch inputs in standard configuration, Pull-up 56k to DVCC 3.3V. Driving it Low or connecting to 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 for zero or background calibration forcing.
Din3	R/T control line for UART connection to RS485 driver.

*Table 1. I/O notations used in this document for the K33 platform with some descriptions and ratings. Please, beware of **the red colored texts that pinpoint important features** for the system integration!*

## Mechanical drawings

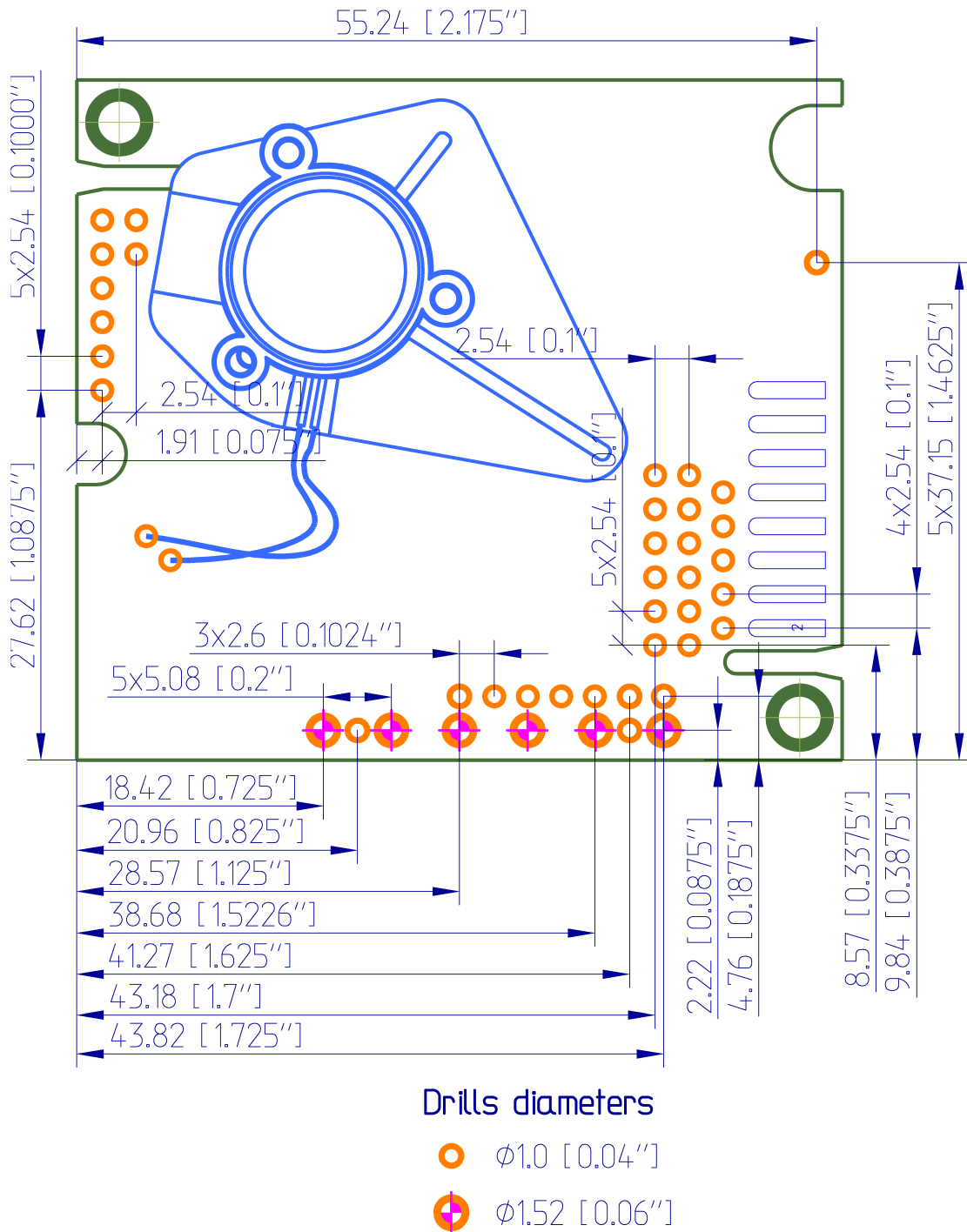


Figure 9 . **CO<sub>2</sub>Engine™ ICB** mechanical drawing. Hole/contacts positions.

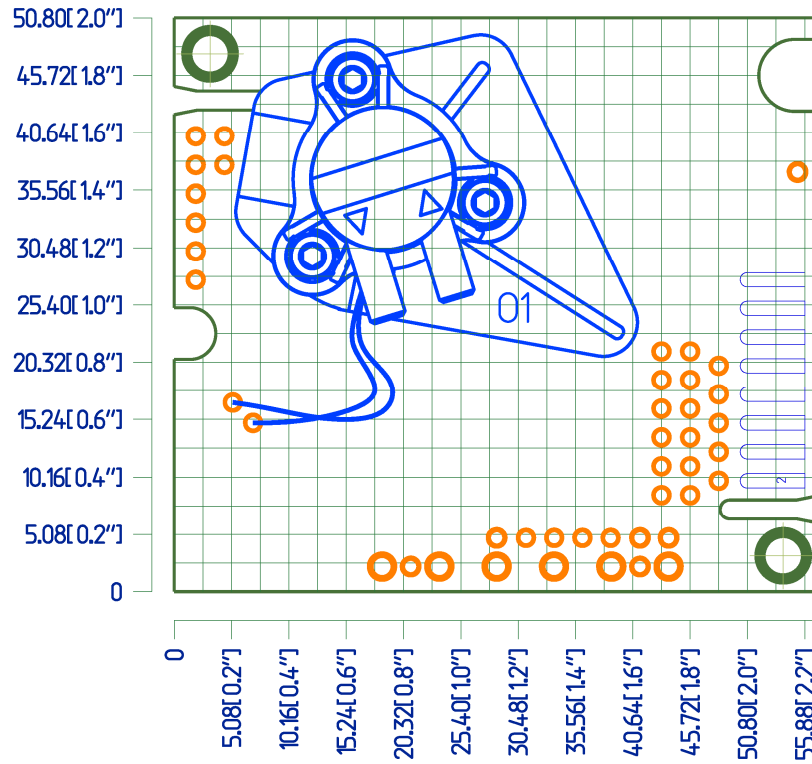


Figure 10a . **CO<sub>2</sub>Engine™ ICB** OBA position. Tube IN/OUT model

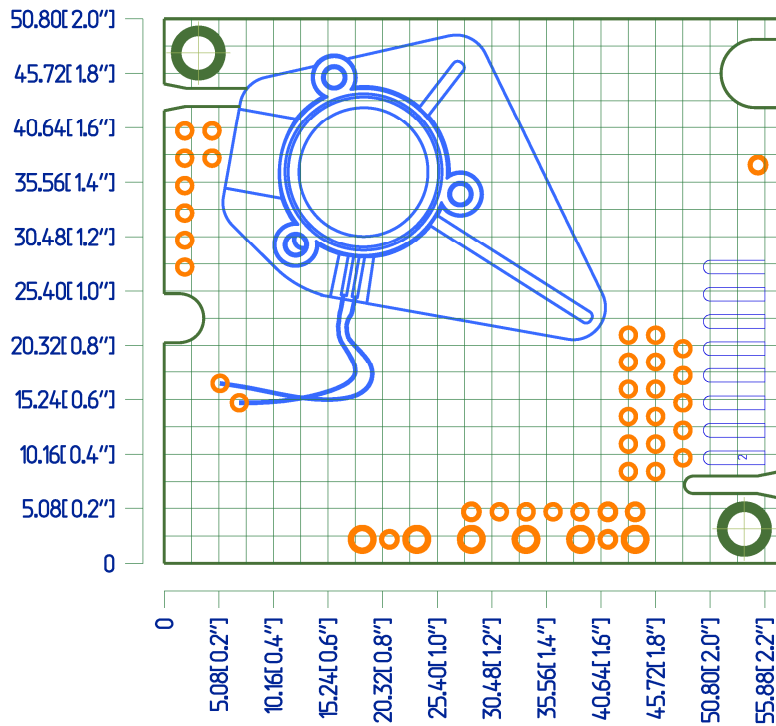
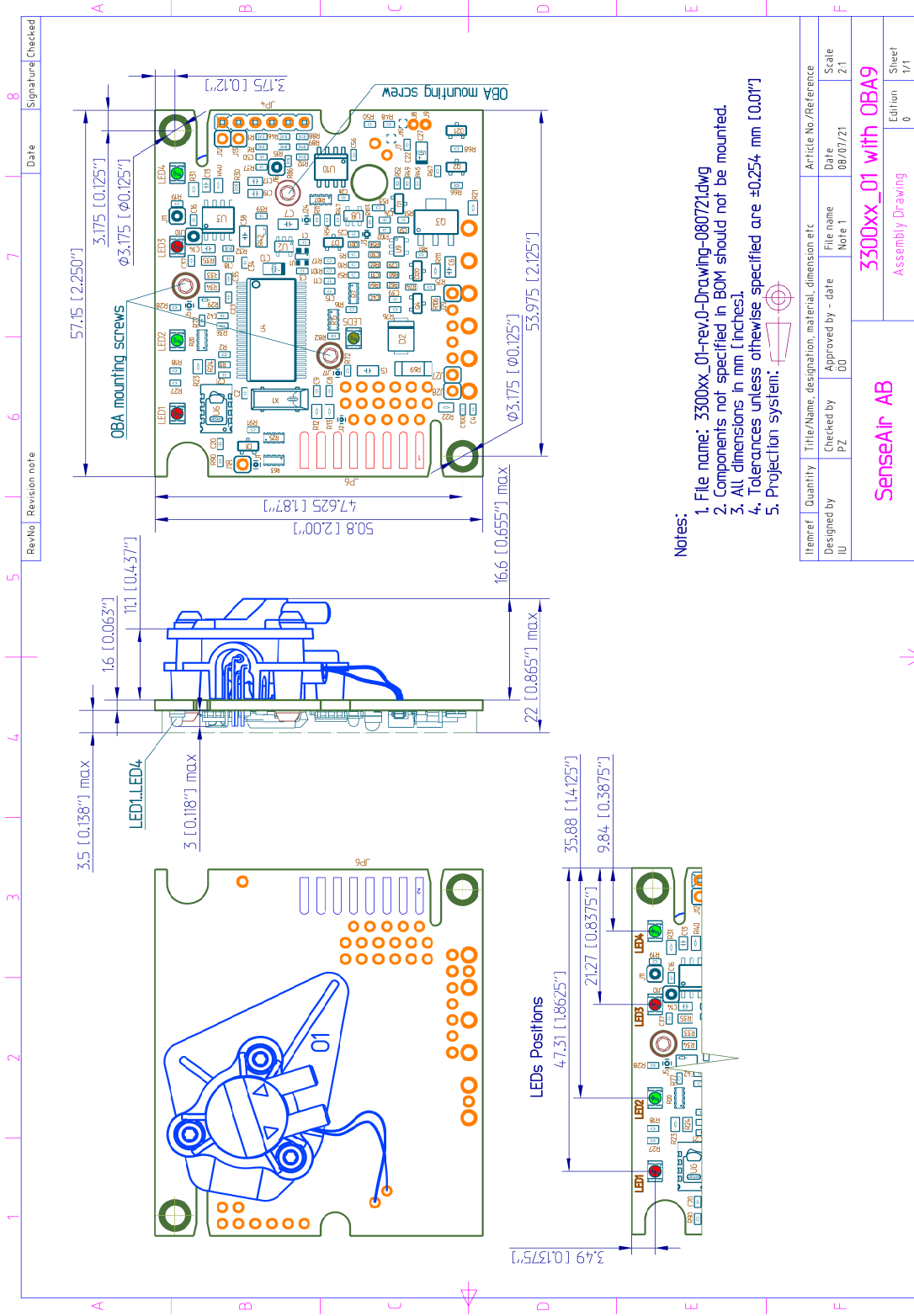


Figure 10b . **CO<sub>2</sub>Engine™ ICB** OBA position. Diffusion model..



- Notes:
1. File name: 3300xx\_01-rev.0-Drawing-080721.dwg
  2. Components not specified in BOM should not be mounted.
  3. All dimensions in mm [Inches].
  4. Tolerances unless otherwise specified are ±0.254 mm [0.01"]
  5. Projection system:

Itemref	Quantity	Title/Name, designation, material, dimension etc	Article No./Reference
Designed by IU	Checked by PZ	Approved by - date 00	Date 08/07/21
		File name Note.1	Scale 2:1
SenseAir AB		3300xx_01 with OBA9	
Assembly Drawing		Edition 0	Sheet 1/1

Figure 11. CO<sub>2</sub>Engine™ ICB mechanical drawing. Tube IN/OUT model

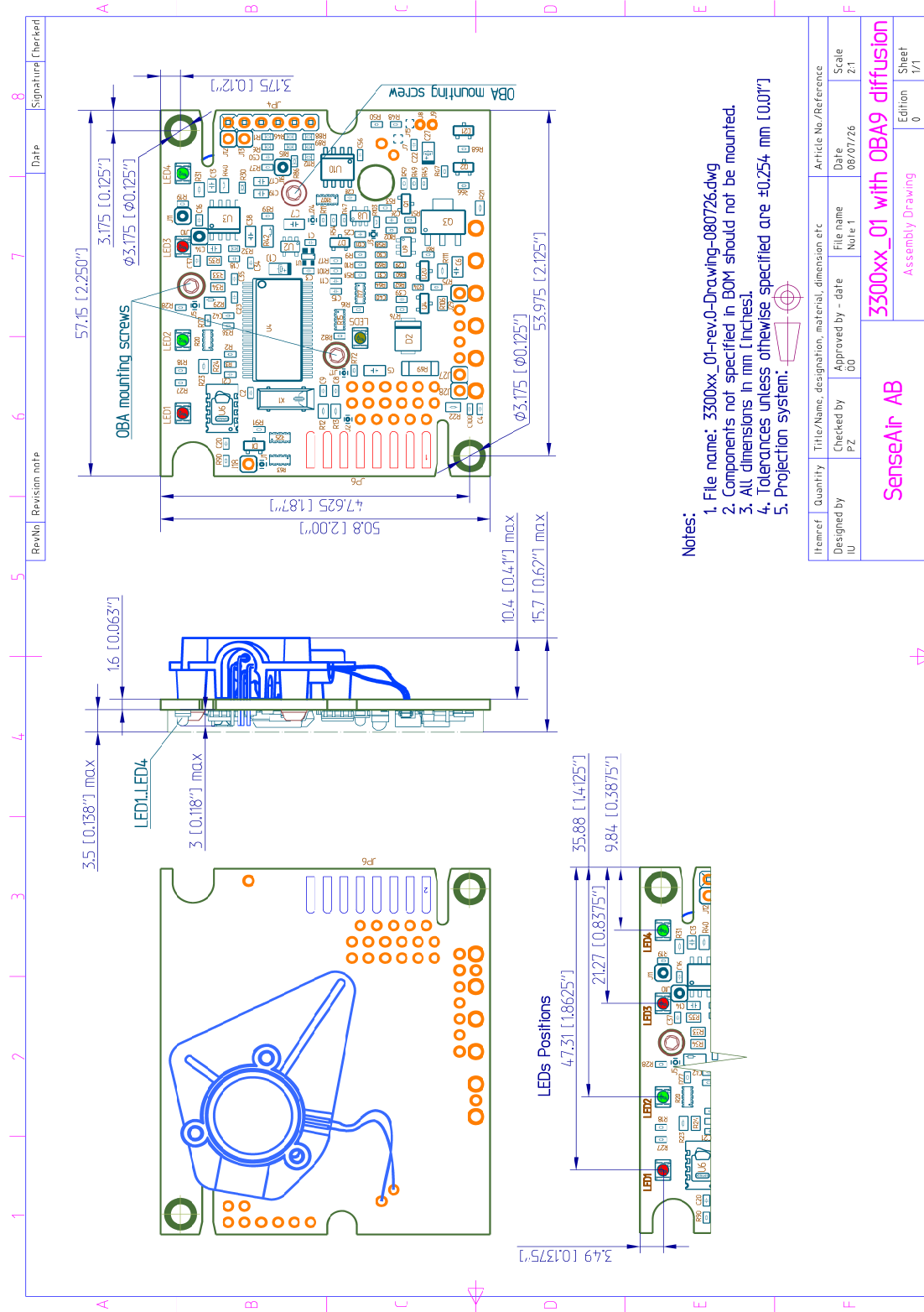


Figure 12. CO2Engine™ ICB mechanical drawing. Diffusion model.

## Ground / Shield attachments

Both Analog ground (AGND) and digital ground (DGND) are connected internally to the G0 terminal of the sensor. AGND is connected to the most sensitive analogue part of the sensor and DGND is connected to the digital part of the sensor.

**Do NOT connect AGND and DGND together externally to sensor!**

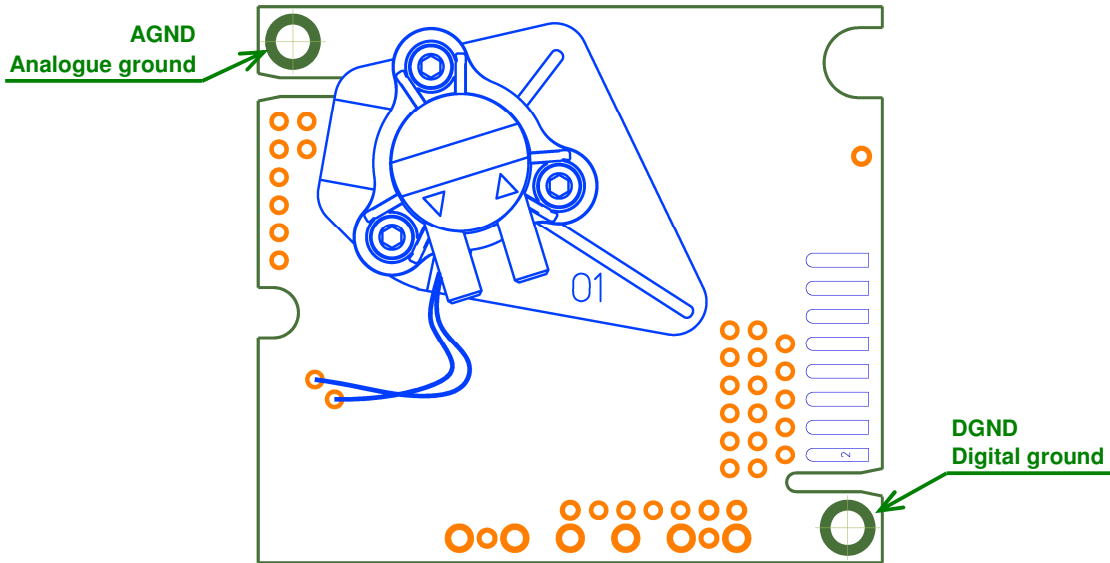


Figure 13 . **CO<sub>2</sub>Engine™ ICB** ground / shield attachment

## Maintenance

When used in environments where the built-in self-correcting **ABC algorithm** can be enabled the **CO<sub>2</sub>Engine™ ICB** is basically maintenance free. Since the ABC algorithm can not be used in all applications it is disabled in sensors default appearance. 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 with enabled ABC algorithm (at least 3 weeks after installation) or after zero/background calibration.

## Calibration

When enabled the **ABC algorithm** (*Automatic Baseline Correction*) 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 0.04%<sub>vol</sub> CO<sub>2</sub>.

Rough handling and transportation might result in a reduction of sensor reading accuracy. If the ABC algorithm is enabled it will tune the readings back to the correct numbers. The default “tuning speed” is however limited. This limit is application specific. In case that the ABC function is disabled (default appearance) or 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<sub>2</sub>). 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<sub>2</sub> (i.e. Nitrogen or Soda Lime CO<sub>2</sub> 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!

Input Switch Terminal (normally open)	Default function (when closed for minimum 8 seconds)
Din1	<b>bCAL</b> (background calibration) assuming 400 ppm CO <sub>2</sub> sensor exposure
Din2	<b>CAL</b> (zero calibration) assuming 0 ppm CO <sub>2</sub> sensor exposure

Table II. Switch input default configurations for **CO<sub>2</sub>Engine™ ICB**

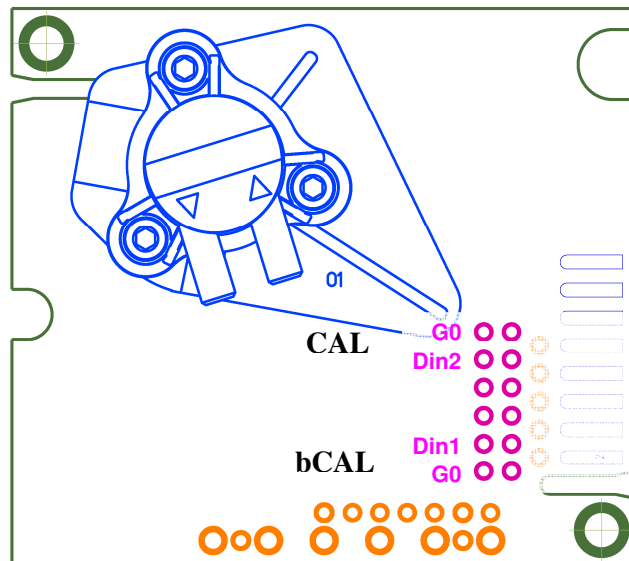


Figure 14. **CO<sub>2</sub>Engine™ ICB** calibration jumpers.

## CO<sub>2</sub>Engine™ ICB- Technical specification (continuous operation)

### General Performance:

Storage Temperature Range .....	-40 to +70 °C
Sensor Life Expectancy .....	> 15 years
Maintenance Interval .....	subject for discussion with customer. Maintenance-free if ABC (Auto Baseline Correction) algorithm is applicable. See discussion of ABC algorithm on page 14.
Self-Diagnostics .....	complete function check of the sensor module
Warm-up Time .....	≤ 1 min
Conformance with the standards.....	EN 61326-1 (2006), Class B emission, Table 2 Industrial location immunity 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. <sup>2</sup>

### Electrical / Mechanical:

Power Input.....	5-14 VDC max rating, stabilized to within 10% (on board protection circuits) <sup>3</sup>
Current Consumption.....	40 mA average < 200 mA average during IR lamp ON (120 msec) < 250 mA peak power (during IR lamp start-up, the first 50 msec)
Electrical Connections .....	terminals not mounted (G+, G0, OUT1, OUT2, Din1, Din2, TxD, RxD) <sup>4</sup>
Dimensions .....	5.1 x 5.7 x 1.4 cm (Length x Width x approximate Height)

### CO<sub>2</sub> Measurement:<sup>4</sup>

Sensing Method.....	non-dispersive infrared (NDIR) waveguide technology with ABC automatic background calibration algorithm
Sampling Method.....	diffusion or flow, subject for discussion with customer
Response Time (T <sub>1/e</sub> ) .....	<20s, diffusion or tube IN/OUT (0.2l/minute gas flow)
Measurement Range .....	0 to 30% <sub>vol</sub>
Digital resolution .....	0.001% <sub>vol</sub>
Repeatability .....	± 0.1 %vol. CO <sub>2</sub> ± 2 % of measured value <sup>1,5</sup>
Accuracy .....	± 0.5 %vol. CO <sub>2</sub> ± 3 % 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 (0.04% <sub>vol</sub> ) CO <sub>2</sub> Din2 switch input to trigger Zero Calibration @ 0 ppm CO <sub>2</sub>

### Linear Signal Output:<sup>4,6</sup>

OUT2 D/A Resolution.....	5 mV
Linear Conversion Range .....	0 - 5 VDC for 0 – 20% <sub>vol</sub>
Electrical Characteristics .....	R <sub>OUT</sub> < 100 Ω, R <sub>LOAD</sub> > 5 kΩ , Power input > 5,5 V <sup>6</sup>

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<sub>2</sub> 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, find possible options in this document and 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 (+-2% currently) is to be added to the specified accuracy for absolute measurements.

Note 6: For the buffered output OUT2 the maximum output voltage range equals power voltage input minus 0,5 V



**PWM Output:**

- Electrical Characteristics .....Open collector with series 120R resistor, 10kΩ pull-up resistor to protected power (+)
- Minimum output concentration .....0%<sub>vol</sub>
- Output cycle period .....1004ms
- Output high level min duration .....2.0ms (@ 0%<sub>vol</sub>)
- Output high level max duration .....1002ms (@ 20%<sub>vol</sub>)
- Resolution .....0.5ms (@0.01%<sub>vol</sub> = 100 ppm)

**Sensor PWM output timing diagram**

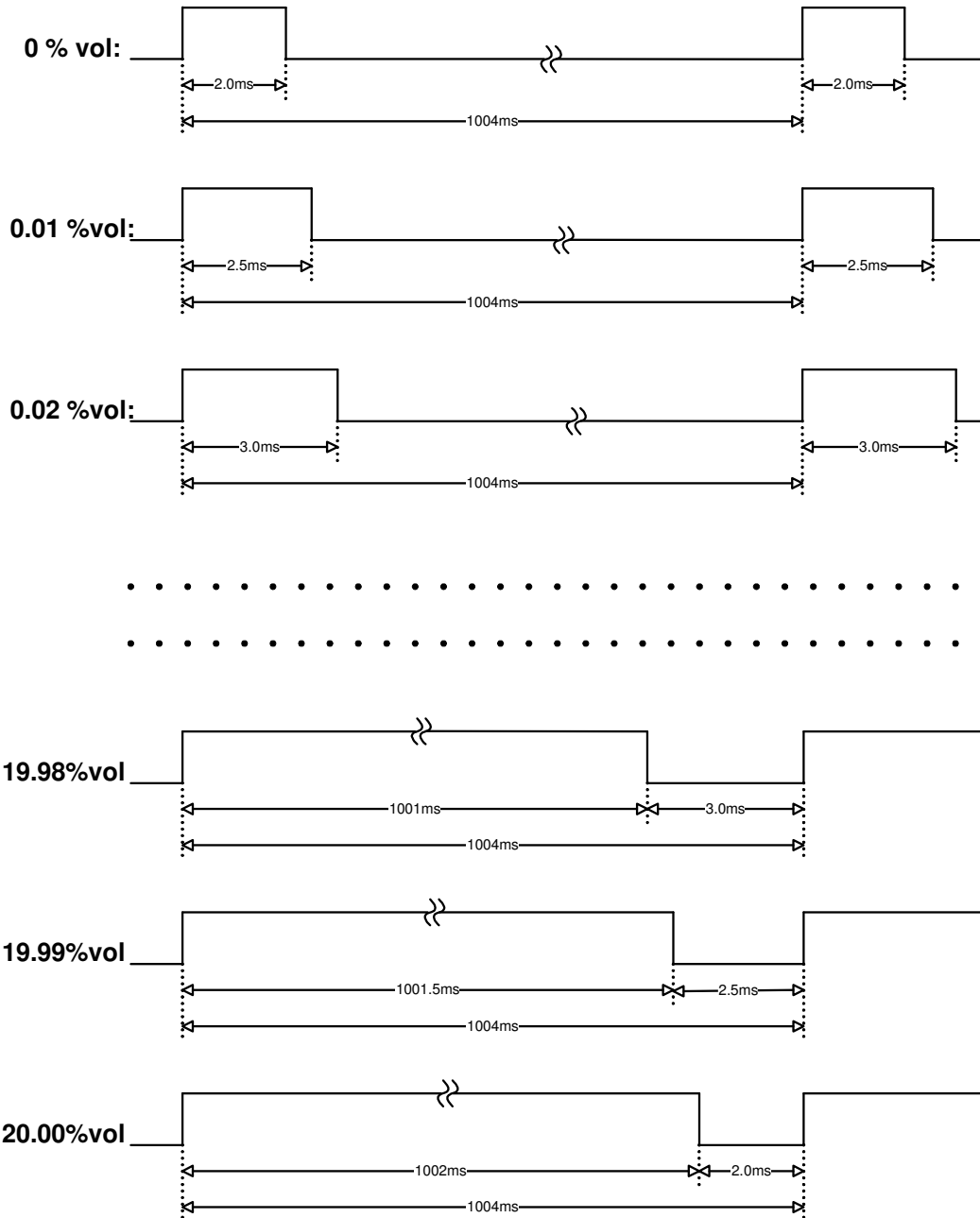


Figure 15. **CO<sub>2</sub> Engine™ ICB** OUT1 timing diagram.

## Materials

Component / coating	Material	Notes
PCB	FR4, Base laminate – copper clad glass base epoxy resin in accordance with IPC-4101/124	
Surface finish of unsoldered copper on PCB	Gold plated, ENIG, thickness 0.05 um min	
Solder mask	Liquid photo-image able	
OBA	LCP700	TBD, it is plastic from LCP family. It's chemically inert plastic stable in most chemicals.
OBA coating	OBA is not coated	Absence of coating provides extra resistance of OBA against corrosive environments

## Gases that may affect sensor's operation

Since optical part has no reflective coating, stability of the sensor is governed by corrosion resistance of electronic assembly.

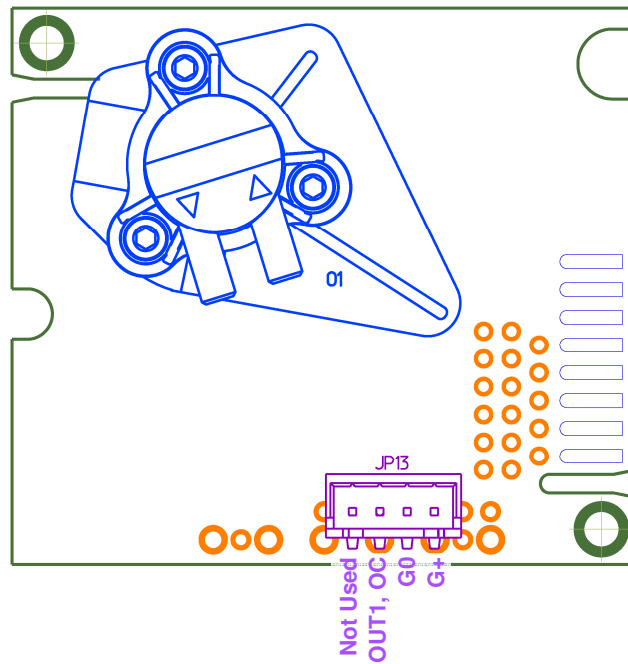
Corrosive environments containing but not limited by hydrogen sulfide, ammonia, ozone, sulphuric acid, sulfur dioxide should be avoided.

## Use ideas (connections)

### Alternative E.

**CO<sub>2</sub> Engine™ ICB** is a stand-alone module connected to the host system by 3-wire interface (JP13 may be chosen to be 3 pole connector) with power supply and open collector output for alarm condition indication. Open collector output may drive LED or relay or buzzer in the case of alarm conditions.

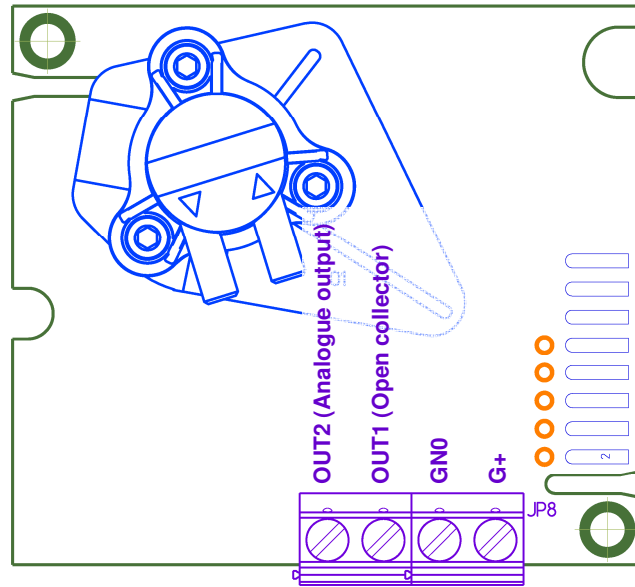
*Open collector may provide PWM signal with duty cycle representing CO<sub>2</sub> concentration*



**Alternative F.**

**CO<sub>2</sub> Engine™ ICB** is a stand-alone module connected to the host system by 3-wire interface (JP8 may be chosen to be 3 pole terminal) with power supply and open collector output for alarm condition indication. Open collector output may drive LED or relay or buzzer in the case of alarm conditions.

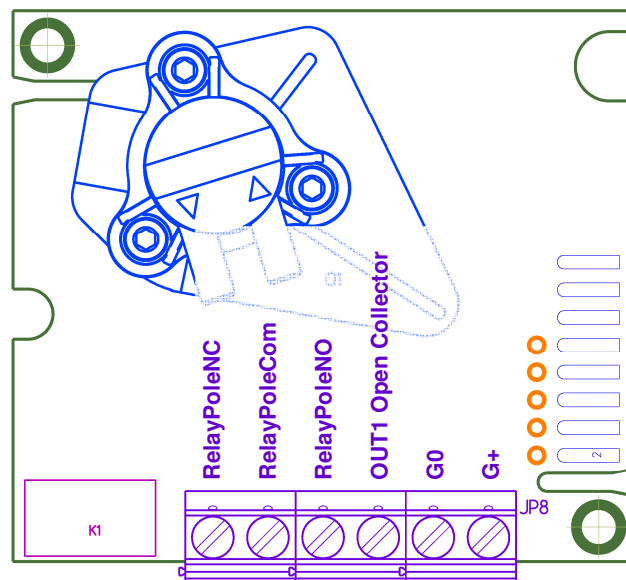
*Open collector may provide PWM signal with duty cycle representing CO<sub>2</sub> concentration*



**Alternative E.**

**CO<sub>2</sub> Engine™ ICB** is a stand-alone module with open collector output and NC/NO relay

*Open collector may provide PWM signal with duty cycle representing CO<sub>2</sub> concentration*



## **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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### Revision history

<b>Edition</b>	<b>Date</b>	<b>By</b>	<b>Description</b>
PA1	2008-05-01	PZ	First appearance
PA2	2008-07-21	IU	Correcting pictures
PA3	2008-07-27	IU	Correcting pictures
PA4	2008-08-07	PZ	Update with new pictures and PWM output.
PA5	2008-08-08	PZ	Added materials chapter.
PA6	2008-08-08	PZ	Convert CNT spec into ICB spec with corrections by HM
PA8	2009-11-02	JA	Correcting pictures
1.00	2011-07-04	LN	Correcting linear conversion range
1.01	2012-05-30	LN	CO2 measurement accuracy updated