Product Manual

CO_2 Engine™ - ICB

Sensor module for bio applications

SE-0025 10% CO2 Sensor Module
SE-0026 30% CO2 Sensor Module
CM-0058 10% CO2 Development Kit
CM-0027 30% CO2 Development Kit

General

- ***CO_2 Engine™** ICB* is targeted for biological applications with required measurement range 0 to up to 30%$_{vol}$ CO_2. This document contains a description of the programming I/O and precise measurements for OEM applications.
- The ***CO_2 Engine™** ICB* is built on the ***CO_2 Engine™ K33 platform.*** This platform is designed to be an OEM module or as a standalone CO2 transmitter/switch module.
- The ***CO_2 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_2 Engine™ *ICB* is built in into the customer's system by connection via JP5. I^2C communication is used to read measured data from the sensor. Detailed description of I^2C communication with useful examples and troubleshooting can be found in "I2C comm guide 2_14.pdf"

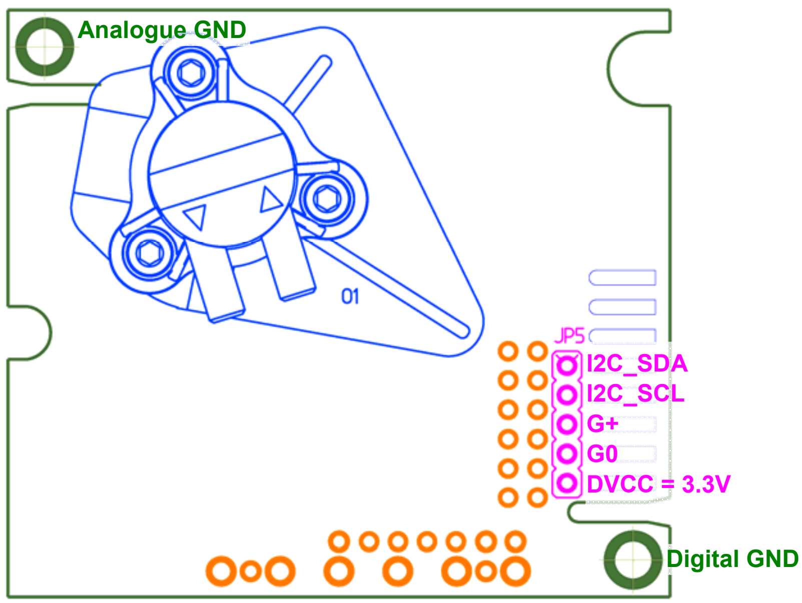


Figure 2. ***CO_2 Engine™ ICB*** *Possible connection terminals for reading via I^2C.*

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

Connection alternative B.

CO_2 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_2 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:

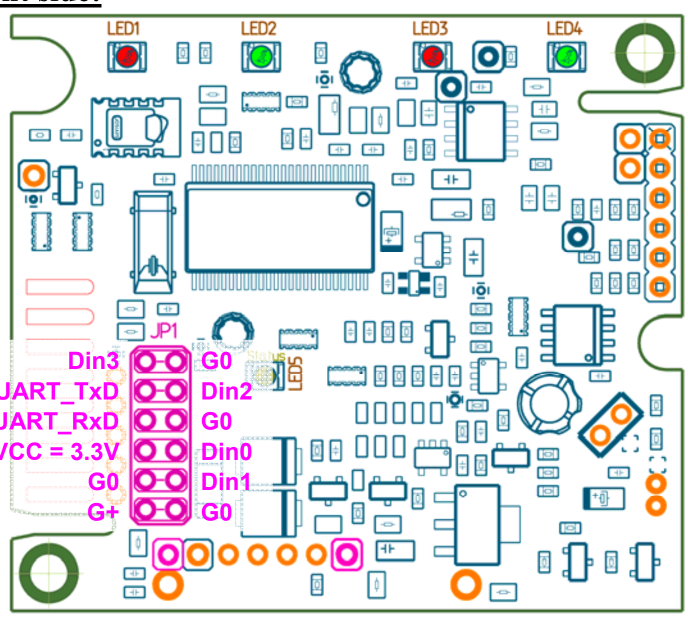


Figure 3a. ***CO_2 Engine™ ICB*** *Possible connection terminals for reading via UART.*

Note: LEDs are optional.

View from OBA side:

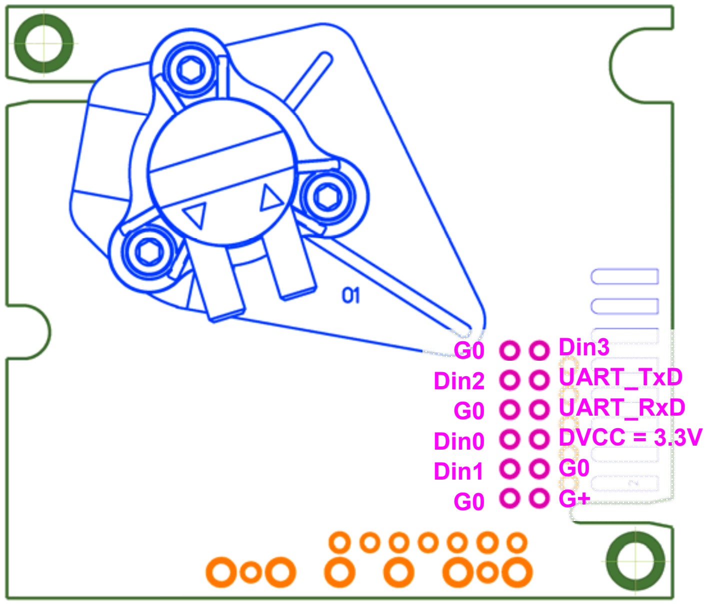


Figure 3b. ***CO_2 Engine™ ICB*** *Possible connection terminals for reading via UART.*

Connection alternative C.

***CO_2 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:

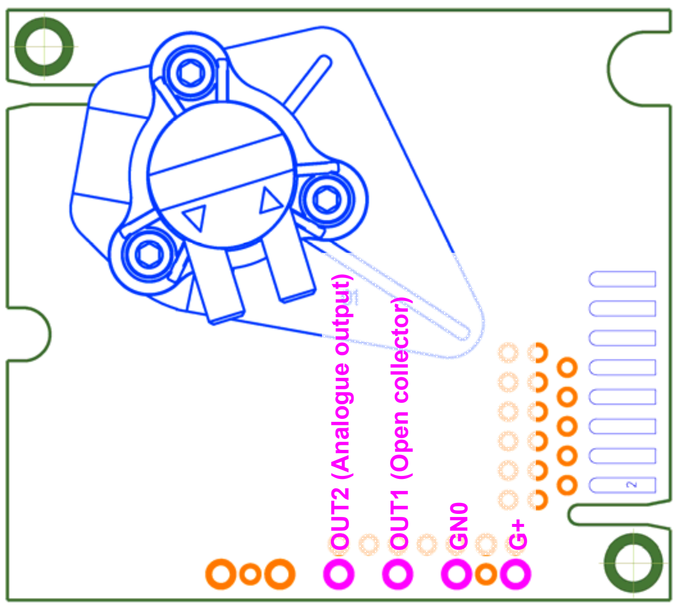


Figure 4a. ***CO_2 Engine™ ICB*** *Possible connection terminals for connection by long wires.*

2 mm pitch:

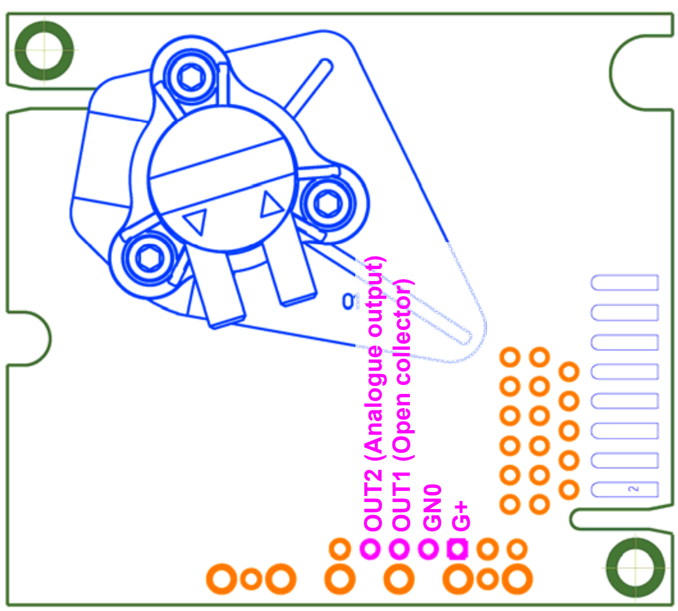


Figure 4b. ***CO_2 Engine™ ICB*** *Possible connection terminals for connection by long wires.*

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.

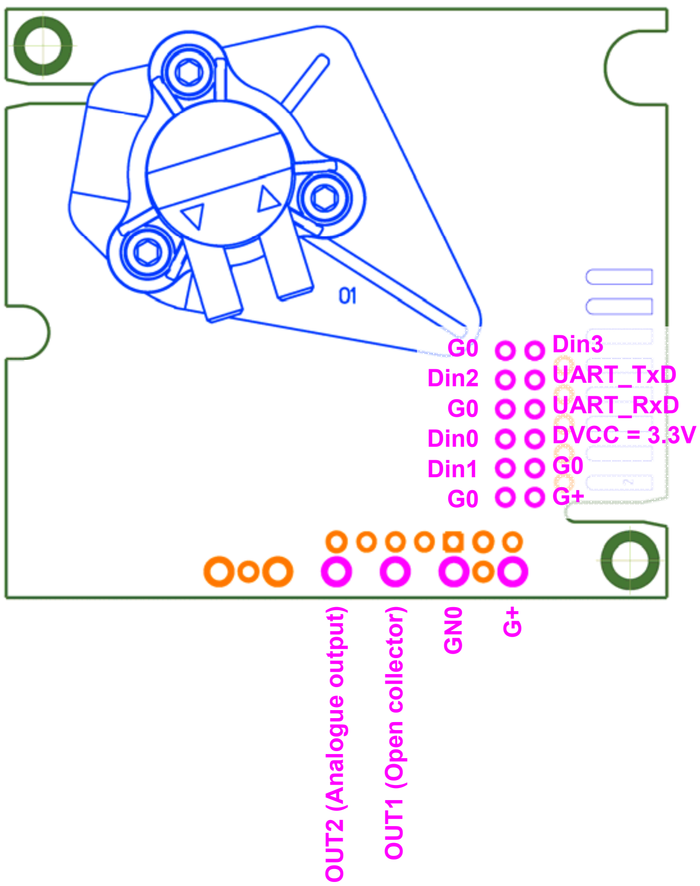


*Figure 5. **CO_2 Engine™ ICB** Possible connection terminals for connection by long wires and UART at the same time.*

Diffusion or tube IN/OUT alternatives

CO_2 Engine™ *ICB* can be supplied in diffusion modification with or without O-ring.

Figure 6. ***CO_2 Engine™ ICB*** *diffusion model.*

CO_2 Engine™ *ICB* can be supplied in tube in/out modification with different orientation of tube attachment head in steps of 120 degrees.

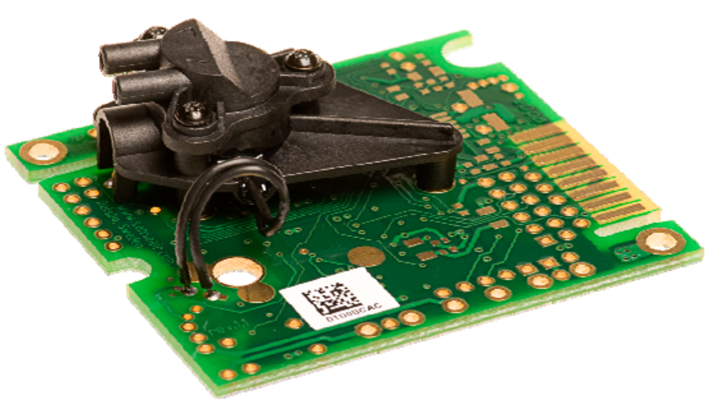


Figure 7. ***CO_2 Engine™ ICB*** *tube IN/OUT model.*

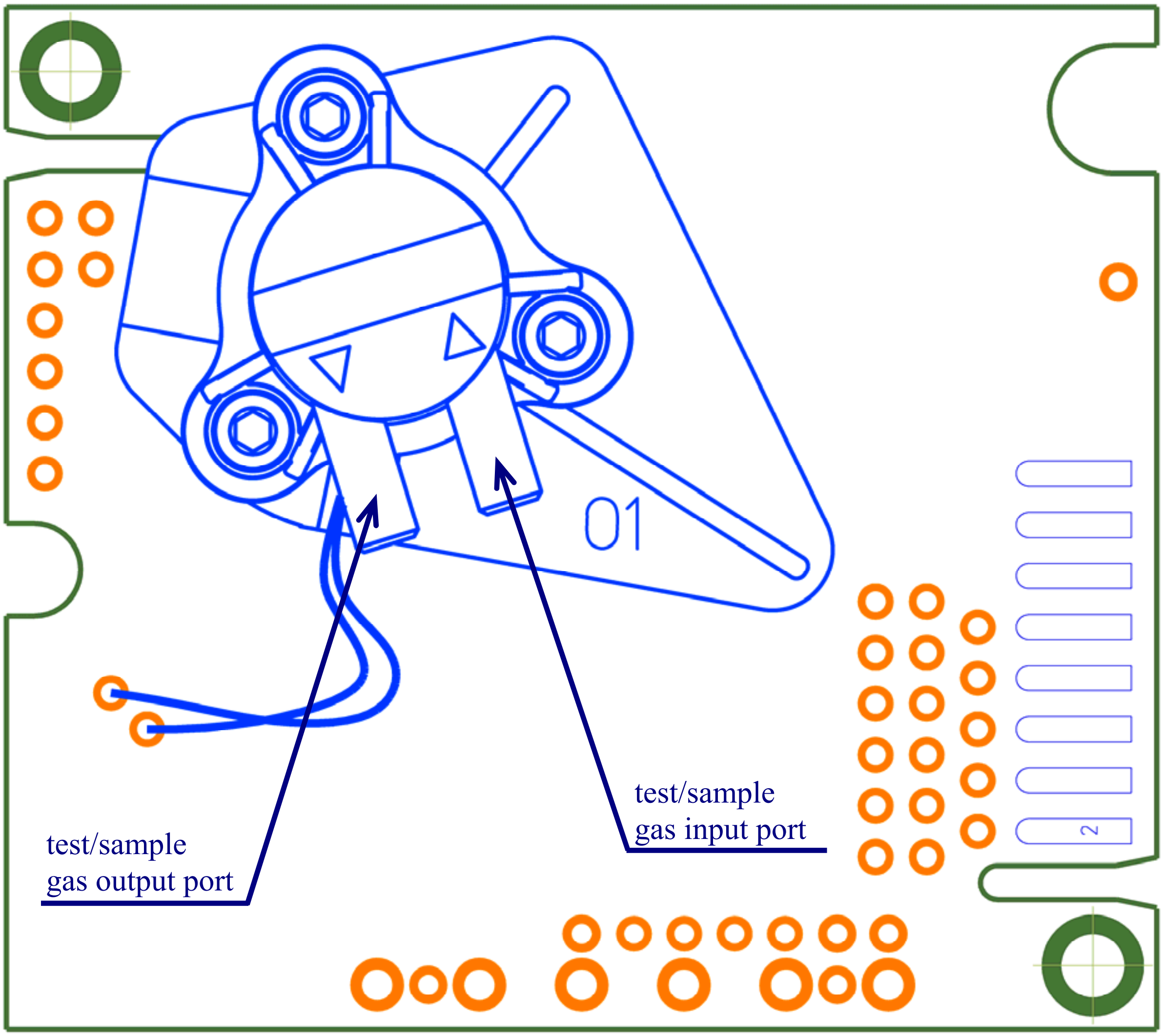


Figure 8a . ***CO_2Engine™ ICB*** *Test/sample gas ports.*

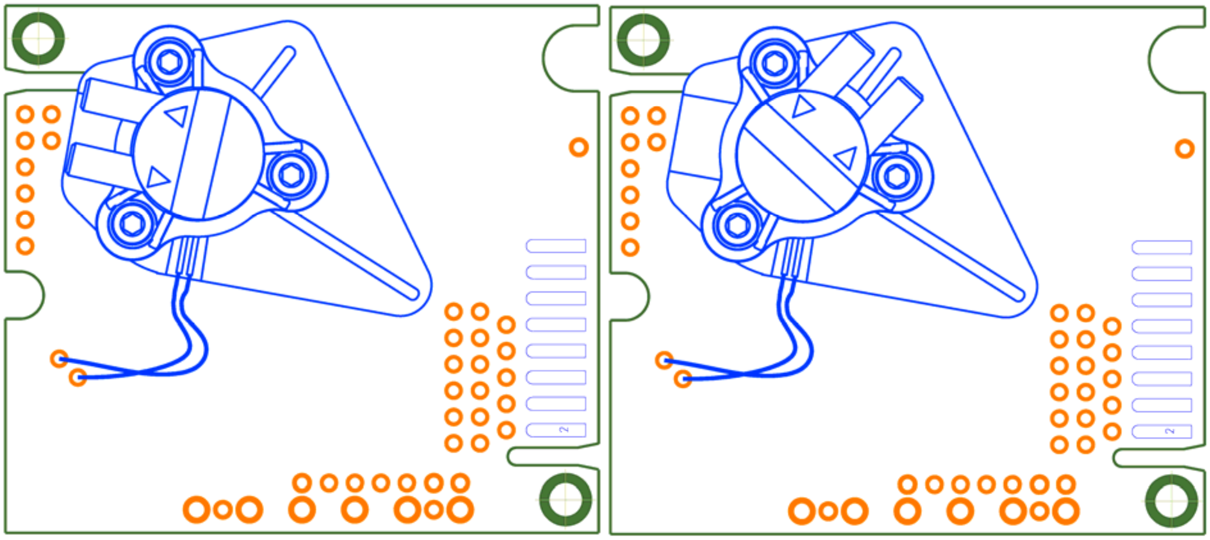


Figure 8b . ***CO_2Engine™ ICB*** *Possible test/sample gas ports installations.*

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
Power supply (all connection alternatives)	
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.
Communication	
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 ABSOLUTE MAX RATING G0-0.5V ….. DVCC + 0.5V
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) ABSOLUTE MAX RATING G0-0.5V ….. DVCC + 0.5V
Outputs	
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 Ω, R_{LOAD} > 5 kΩ **Load to ground only!** Resolution 5mV
RELAY (RelayPoleNC RelayPoleCom RelayPoleNO)	RELAY It's not a standard option. Maximum switching capability 1A/50VAC/24VDC
Digital I/Os, used as Inputs in standard configuration. May be implemented as jumper field	
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 I. 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

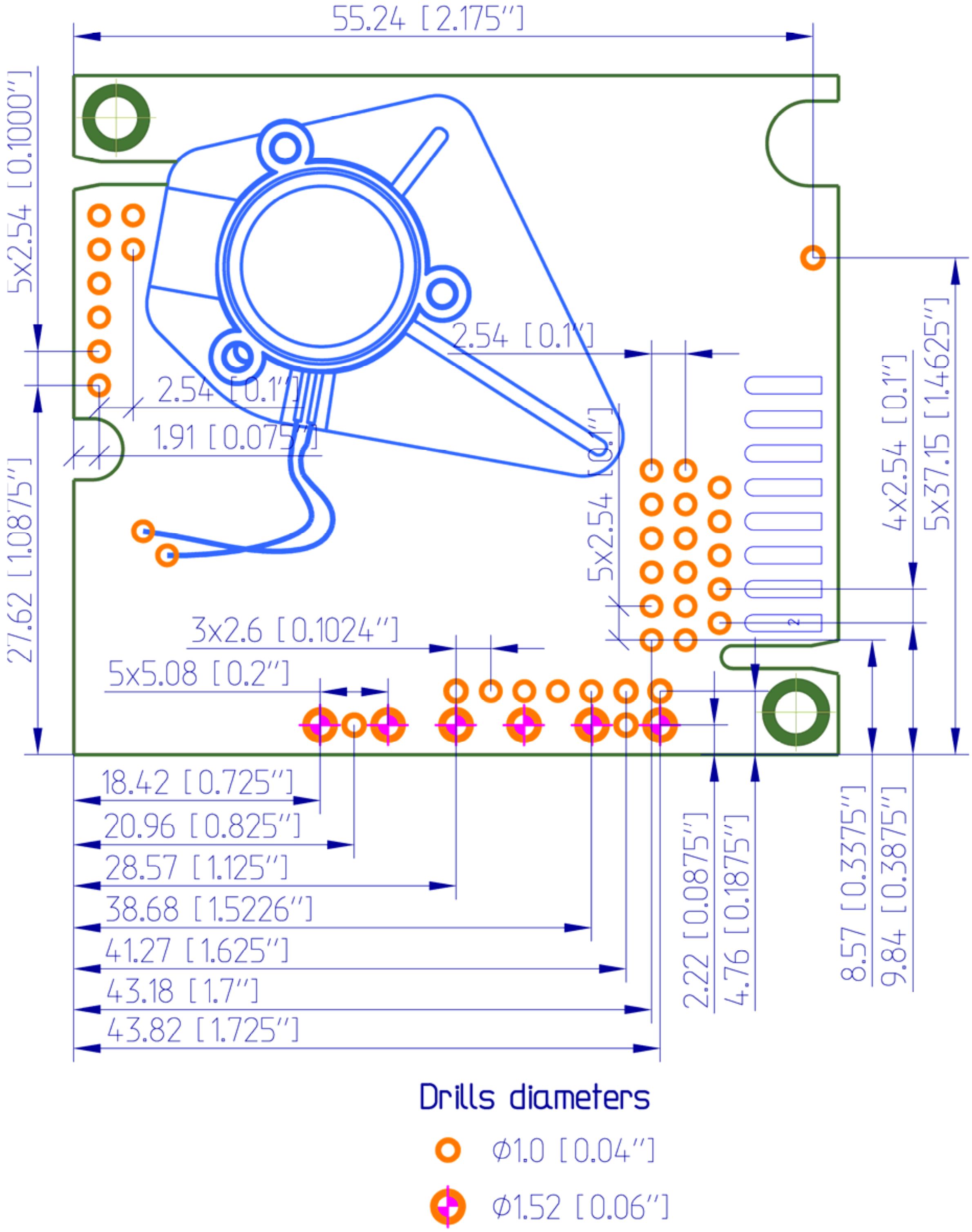


Figure 9 . ***CO_2Engine™ ICB*** *mechanical drawing. Hole/contacts positions.*

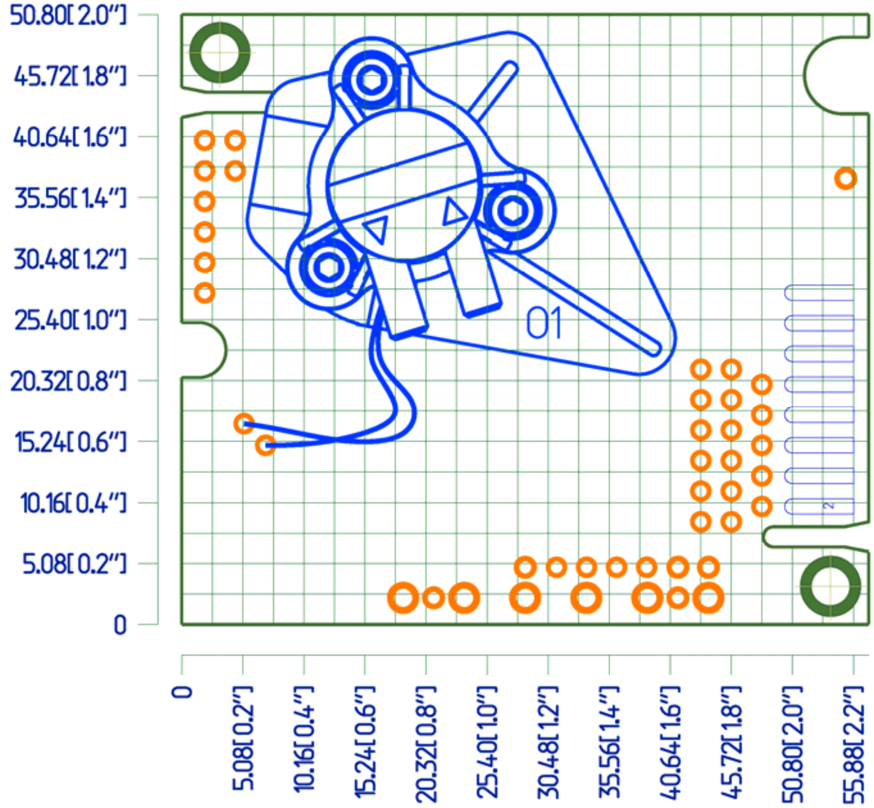


Figure 10a . ***CO_2Engine™ ICB*** *OBA position. Tube IN/OUT model*

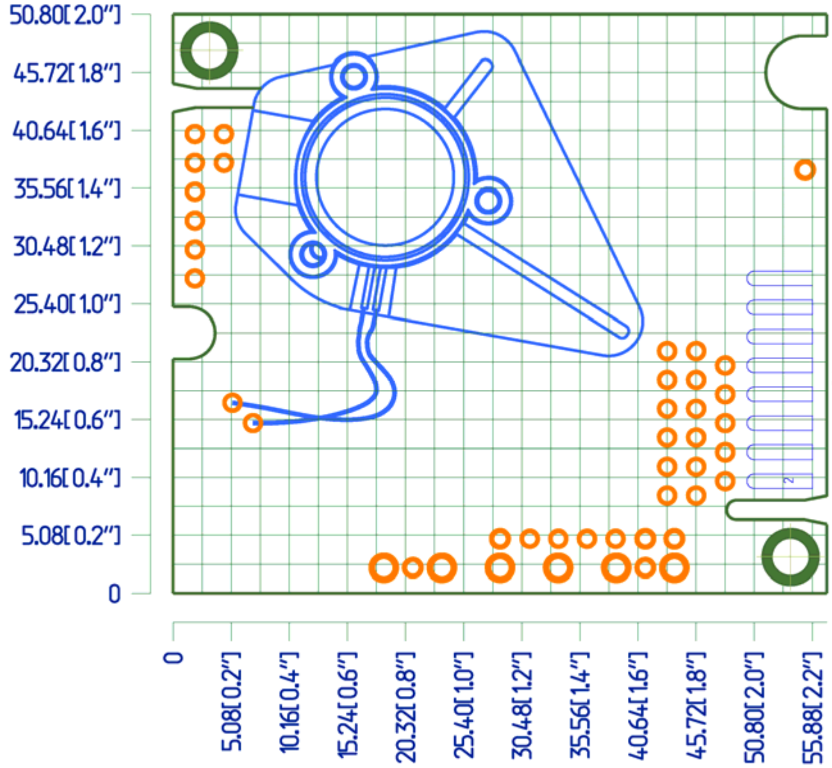


Figure 10b . ***CO_2Engine™ ICB*** *OBA position. Diffusion model..*

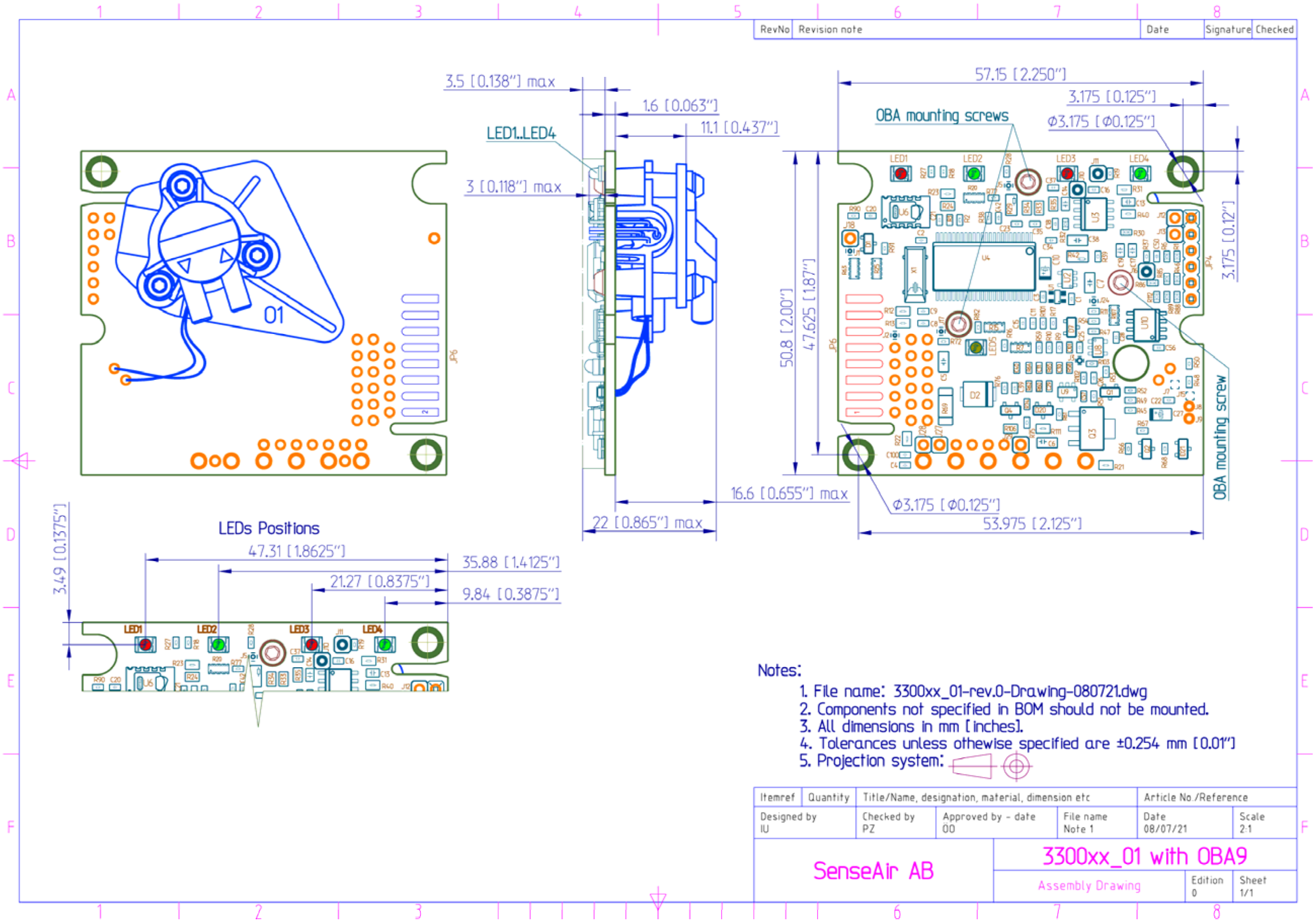


Figure 11 . ***CO_2Engine™ ICB*** *mechanical drawing. Tube IN/OUT model*

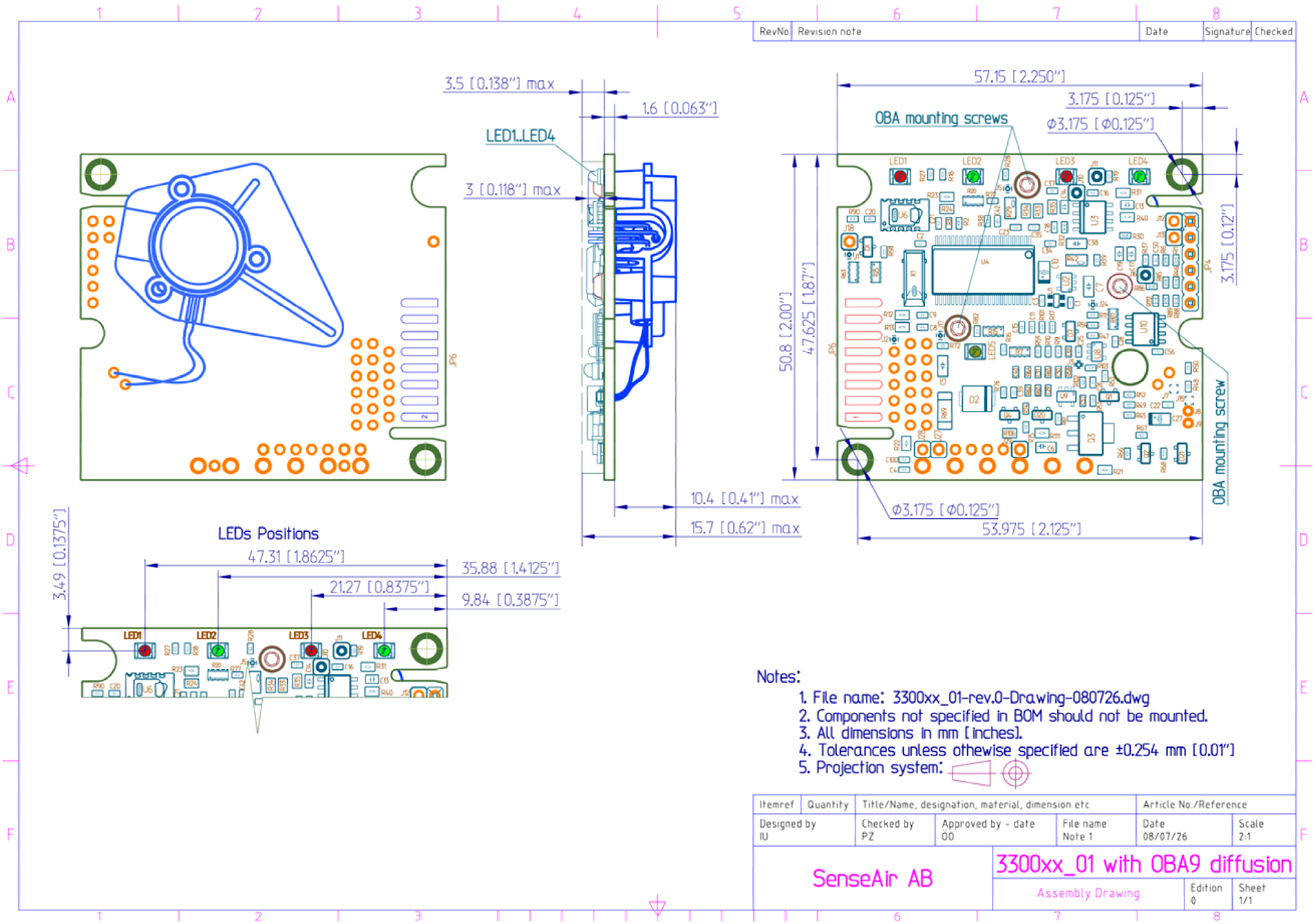


*Figure 12 . **CO_2Engine™ ICB** mechanical drawing. Diffusion model.*

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!

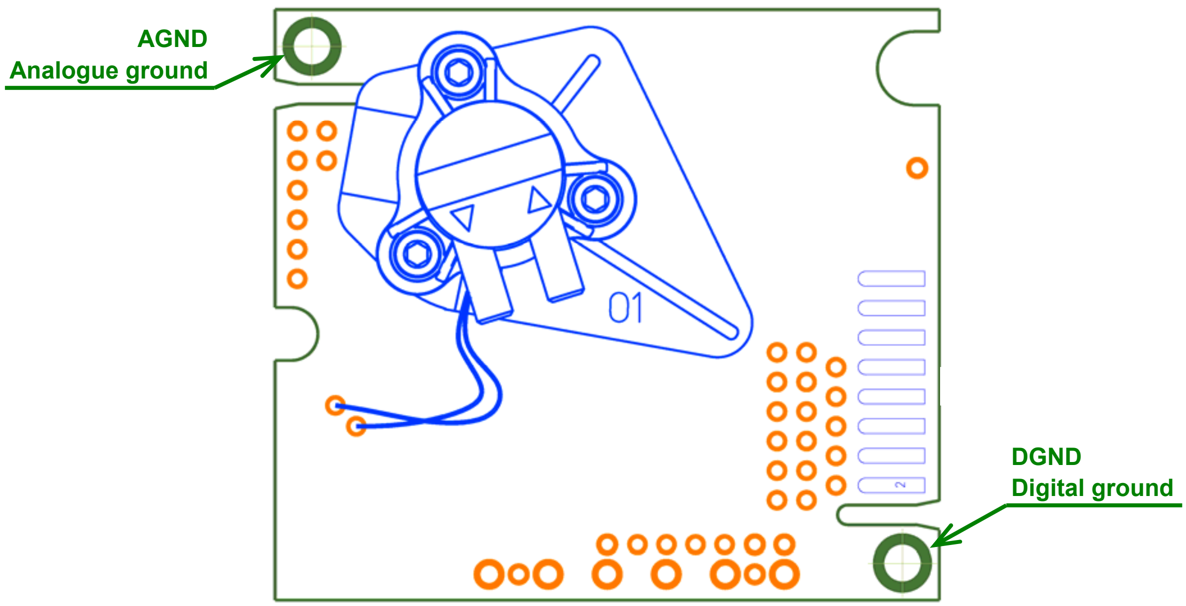


Figure 13 . ***CO_2Engine™ ICB*** *ground / shield attachment*

Maintenance

When used in environments where the built-in self-correcting ***ABC* algorithm** can be enabled the ***CO_2Engine™ 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 $0.04\%_{vol}$ CO_2.

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_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!

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 II. Switch input default configurations for ***CO_2Engine™ ICB***

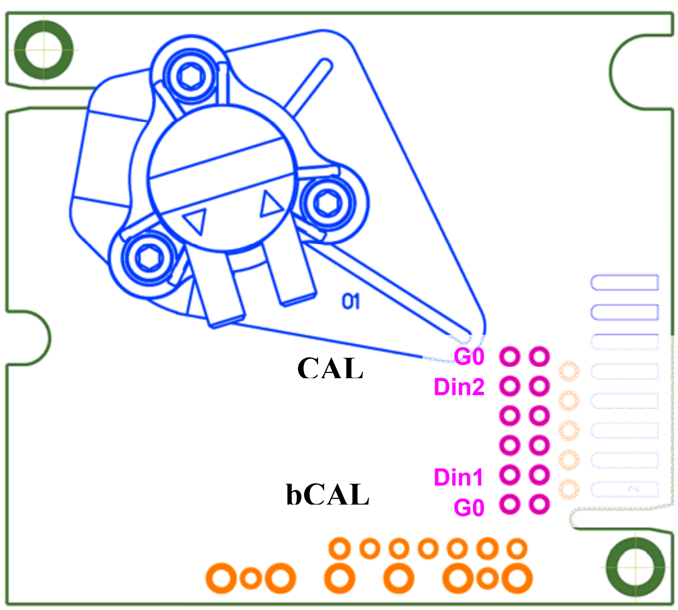


Figure 14. ***CO_2 Engine™ ICB*** *calibration jumpers.*

CO_2Engine™ 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.[2]

Electrical / Mechanical:

Power Input ....5-14 VDC max rating, stabilized to within 10% (on board protection circuits) [3]
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[4] ....terminals not mounted (G+, G0, OUT1, OUT2, Din1, Din2, 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 or flow, subject for discussion with customer
Response Time ($T_{1/e}$) ....<20s, diffusion or tube IN/OUT (0.2l/minute gas flow)
Measurement Range ....0-30% or 0-10% volume CO2
Digital resolution....................................0.001% vol.
Repeatability 10% sensor ....± 100ppm vol. ± 1% of measured value
Repeatability 30% sensor ....± 0.1% vol. ± 2% of measured value
Accuracy 10% sensor[1, 5] ....± 100ppm vol. ± 1% of measured value
Accuracy 30% sensor[1, 5] ....± 0.5% vol. ± 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%$_{vol}$) CO_2
Din2 switch input to trigger Zero Calibration @ 0 ppm CO_2

Linear Signal Output: [4,6]

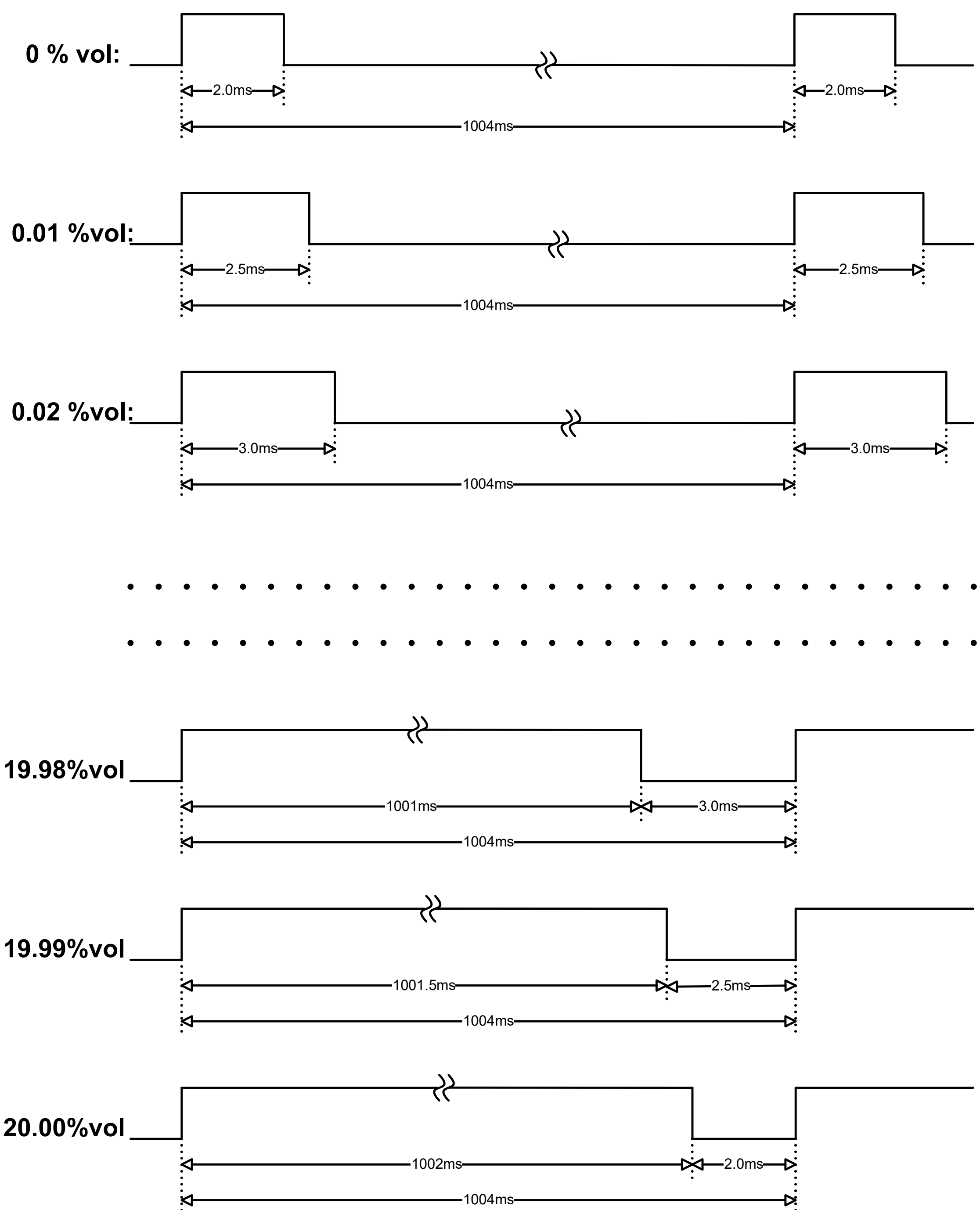
OUT2 D/A Resolution..........................5 mV
Linear Conversion Range ....0 - 5 VDC for 0 – 20%$_{vol}$.
Electrical Characteristics ....R_{OUT} < 100 Ω, R_{LOAD} > 5 kΩ, Power input > 5,5 V [6]

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, 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 .... $0\%_{vol}$
Output cycle period 1004ms
Output high level min duration .... 2.0ms (@ $0\%_{vol}$)
Output high level max duration ...... 1002ms (@ $20\%_{vol}$)
Resolution .... 0.5ms (@$0.01\%_{vol}$ = 100 ppm)

Sensor PWM output 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

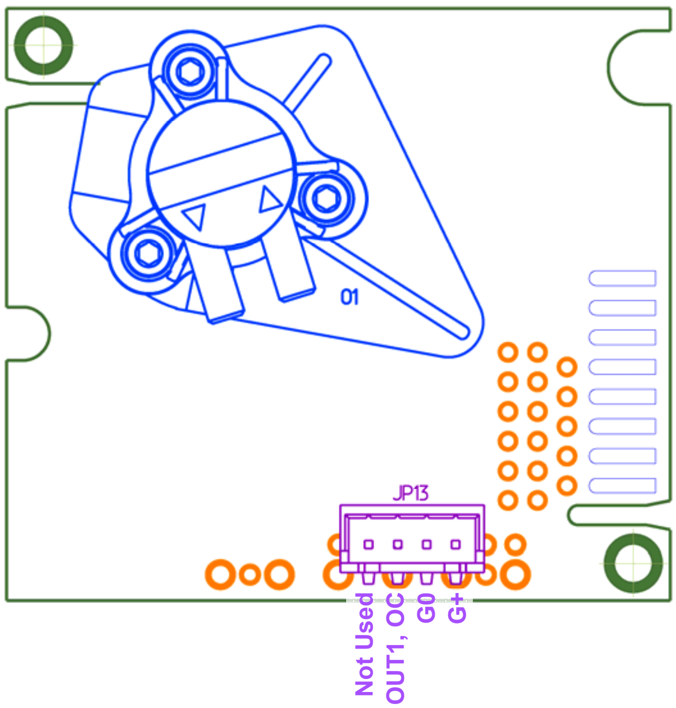
Since optical part has no reflective coating, stability of the sensor is governed by corrosion resistance of electronic assembly.
Corrosive environments containing but not limited by hydrogen sulfide, ammonia, ozone, sulphuric acid, sulfur dioxide should be avoided.

Use Ideas (connections)

Alternative E.

CO_2 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.

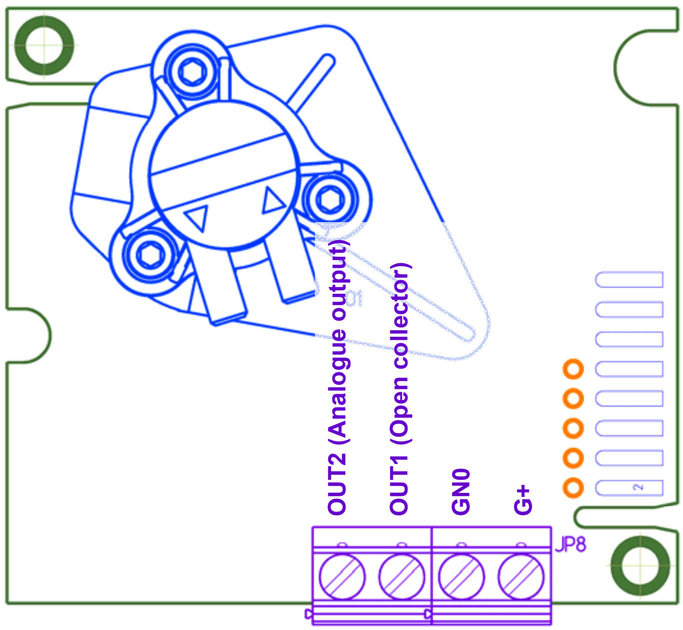
Open collector may provide PWM signal with duty cycle representing CO2 concentration



Alternative F.

CO₂ 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.

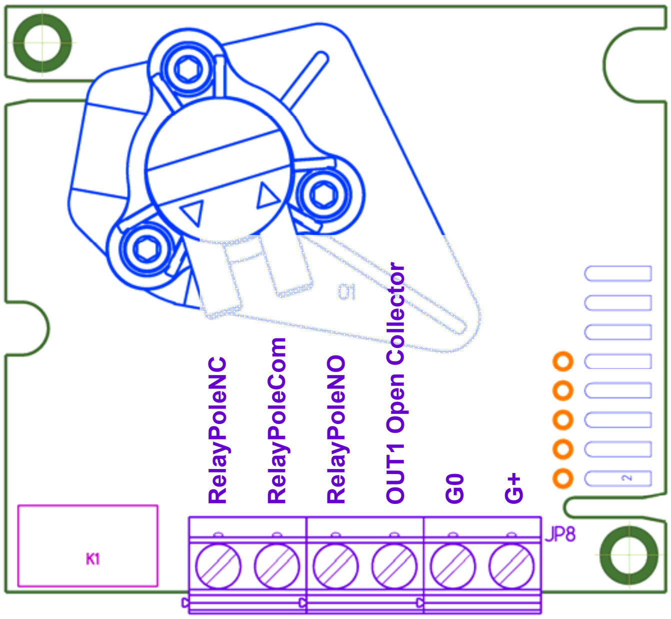
Open collector may provide PWM signal with duty cycle representing CO2 concentration



Alternative G.

CO_2 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 CO2 concentration



Frequently Asked Questions – Programming

1- If I send the stop command, Is it only the CO2 measurement process that is stopped, or is the sensor not going to respond to any other request except a start measurement request?

   When receiving a stop command sensor finishes its present task and goes into sleep mode (to minimize current consumption), in sleep mode sensor wakes up periodically (1s) and for example check the jumper, activity on the communication lines will also wake up the sensor (see I2C communication guide for details)

2- If I stop the measurement, are all the other functions still active, can I still read/write from the sensor? Can I still read the last CO2 value and temperature while the sensor is stopped?

   Yes, communication is possible after stop measurement.

3- When a start measurement CMD is sent, what is the delay to the effective start of the measurement process (how much time after is the sensor normally starting to hold the bus CLK)?

   Standard time to measurement is 1 minute (same for start measurement command and jumper set), measurement sequence takes ~20s

4- How quickly (immediately?) after the end of the bus hold can I send a stop command ? or is it better to leave the sensor running for a minimum delay?

   It is recommended to wait until after measurement sequence has finished and you have read new data before sending stop command (~80s)

5- Should the light stop flashing when the stop measurement command is sent?

   Not immediately, sensor will finish ongoing measurement sequence before going to sleep – stop measuring

Revision history

Edition	Date	By	Description
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

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