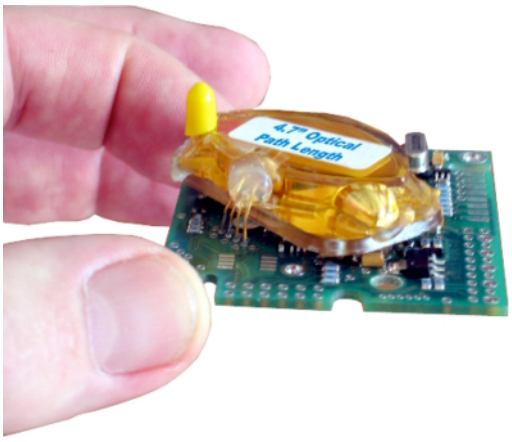
The CO_2 Engine™ Infrared Gas Sensing For OEM Applications

CO_2 Engine™ Overview

AirTest is pleased to introduce the CO_2 Engine™, a working, pre-calibrated CO_2 measurement module that can be readily integrated as an OEM component into controls and equipment. This compact infrared sensor design can be provided with a choice of a variety of optical sensors, each optimized for the CO_2 measurement range desired (up to 25% CO_2 concentrations). The CO_2 engine gives companies immediate access to a proven ISO-9001 built CO_2 measurement product without the need to invest in the considerable research and development necessary to develop a similar product in house. The module is targeted at companies who anticipate product volumes in excess of 1,000 units annually.

The CO_2 Engine™ features an optical sensor with a unique, patented, folded path design that can deliver an extended optical path length in a small physical design. This extended path length, typically limited by packaging size for competitive sensors, will yield dramatic improvement in signal to noise response of the sensor that impacts accuracy, sensor drift and long-term stability. This product is also one of the few infrared CO_2 sensors completely built and assembled in an ISO-9001 certified facility. This certification ensures that the product is built in a consistent manner utilizing standardized procedures and inspection to ensure that all the products you receive meet your required specifications.

Infrared-based measurement of gases can be highly specific. The low cost optical detection methods used by AirTest for CO_2 measurement can also be applied to other gases such as hydrocarbons, water vapor, carbon monoxide and nitrous oxide.



Working With AirTest

AirTest can work with your company to make minor modifications to the CO_2 Engine™ to meet your specific needs. These modifications can include:

- *Re-configuration of outputs (output range, control functions, alarm levels, etc.).*
- *Re-configuration of self-calibration algorithms (auto-calibration strategies).*
- *Hardware modifications (mounting of terminals, connector pins, or pigtails).*

For the appropriate applications AirTest can also work with OEM's to modify the CO_2 Engine™ design to meet specific packaging or performance requirements utilizing our ISO-9001 design processes. Examples of the types of modifications possible include:

- *Hardware modifications (another OBA / optical cell, additional probe inputs, i.e. thermistor, RH, pressure, etc.).*
- *Configuration for new / additional measurement tasks (different gases / ranges / external probes / switches, etc.).*
- *Adjustment and optimization of the gas measurement range through the use of different optical sensor designs.*
- *Micro-controller software modification (non-standard communication protocol, new algorithms, etc.).*

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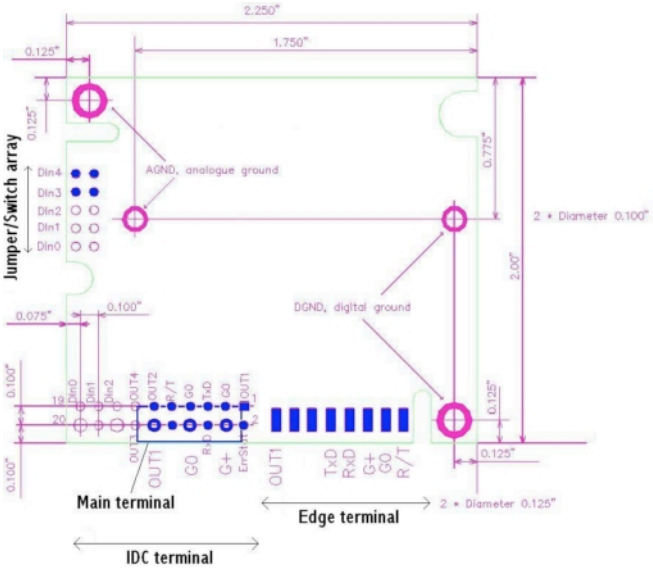
Product Description

The table below specifies what terminals and I/O options are available with the CO_2 Engine™. Please note, however, that in the standard CO_2 Engine™ default configuration, only OUT1, OUT2, Din3, Din4 and ErrStatus have any pre-programmed functions. These are further described in the section *Default Configurations*. A number of different OEM customization options are also presented in the Enhanced Options section of this document.

Function	Descriptions and ratings
Power Supply	
G+ referred to G0:	Absolute maximum ratings: 5.4V to 15V, stabilized to within 10%, 5.7V to 9V preferred operating range. **Unprotected against reverse polarity!**
Serial Communication	
UART (TxD, RxD, R/T)	CMOS **unprotected**. Supports communication in RS485 nets with industry standard MAX485 transceivers. Customer can order communication protocol like SA-bus (proprietary) or ModBus.
Outputs	
OUT1	Buffered linear output 0-4 or 1-4VDC or 0-10V or 2-10V, depending on specified power supply and sensor configuration. **Load to ground only!** Resolution 10mV (8.5 bits in the range 0-4V).
OUT2	**Unbuffered** linear output of DAC. Capacitive load is not allowed. Internal resistance appr. 1kOhm. Output range 0 to 4.370V. Resolution appr. 4mV (10 bits). Precision +-20mV+-1%. 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. Can be used for gas alarm indication, or for status indication etc.
OUT4	CMOS **unprotected.** Digital (High/Low) output or alternatively PWM output. Can be used for gas alarm indication, or for status indication etc. Alternatively, to transmit measured value as PWM.
ErrStatus	CMOS **unprotected.** PWM indication of sensor status and calibration acknowledgement. Contact SenseAir for a detailed specification!
Inputs	
Din0, Din1, Din2	Digital switch inputs, pull-up 5k1 to DVCC (5V). 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 5k1 to DVCC (5V). Notice that the first 3 are the same as 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.
SPI Extension Connector	
Contact AirTest for information	SPI connection enables direct connection to master processor. For example, connection to a Neuron processor for LonWorks® standard networks.

CO_2 Engine Configuration



CO_2 Engine™ I/O notations, terminal positions and some important dimensions for mounting the K10 platform PCB into a host system (component layer view). The blue filled pins are defined by default.

CO_2 Engine™ Installation

The CO_2 Engine modules are factory calibrated and ready for use directly after power up. There are 3 alternative ways to connect the CO_2 Engine™ to a host system (see also figure 2):

1. Using the **edge connector,** including terminals for power supply (G+ and G0), UART with RS485 connection possibility (TxD, RxD and R/T), and buffered analog output (OUT1). **The two unspecified pins must be left unconnected** without capacitive or any other load. **Do not connect the pins to any cable!**

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 CO_2 Engine™ to a host PCB, this connector can in some situations be used as the only fixture. When mounting CO_2 Engine™ PCB using mechanical poles and screws, no more than 2 points of mounting 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 *analog* ground. They are the choices of preference 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! Unstable sensor readings indicate either there is a need for shielding or there is improper enclosure system grounding.

- 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. Regardless, the sensor may be powered via these connections.

Note 1: To avoid ground loops, avoid connecting the analog and digital grounds externally! They are connected internally on the CO_2 Engine™ 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_2 Engine™ 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 (SA protocol), together with additional system information such as sensor status, analog outputs, and other variables.

Terminals	Output	Description/Status
OUT1 and OUT2	1,0…4,0 VDC 0,4…0,6 VDC 0 VDC	0…2000 ppm CO_2 Status = ERROR Status = NOT READY

Default analog output configuration for the CO_2 Engine™.

Calibration: The default sensor OEM unit is maintenance free in normal environments thanks to the built-in self-correcting ***A B C* algorithm** *(Automatic Baseline Correction)*. This algorithm constantly keeps track of the sensor's lowest reading over a 7 to 5 day 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 Din3 and Din4 are defined for the operator to select one out of two prepared calibration codes. If Din3 is shorted 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 Din4 is shorted instead, 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).

Input Switch Terminal *(normally open)*	Default function *(when momentarily closed)*
Din3	**bCAL** (background calibration) assuming 400 ppm CO_2 sensor exposure
Din4	**CAL** (zero calibration) assuming 0 ppm CO_2 sensor exposure

Switch input default configurations for the CO_2 Engine™.

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 ErrStat will be put into a modulated state. The full error codes are available from the UART port. 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 after return to normal by UART overwrite, or by power off/on.

Output Terminal	Default Function
ErrStat	**High level** = OK; **Modulated level** (PWM duty cycle about 0,5) = FAULT

Default Logic output configured for the CO_2 Engine™.

Maintenance

The CO_2 Engine™ is maintenance free in normal environments thanks to the built-in self-correcting *ABC* algorithm. Discuss your application with AirTest 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)!

Warranty & Limitations Of Liability

1. AirTest warrants that for a period of twenty-four (24) months following receipt by Buyer the Product supplied by AirTest to Buyer will be, under normal use and care, free from defects in workmanship or material and to be in material conformity with AirTest's specifications. Units returned to AirTest for warranty repairs shall be shipped to AirTest, at Buyer's expense, according to AirTest's instruction. Within ninety (90) days of the receipt of product, AirTest 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 AirTest instructions; that has been affixed to any non-standard Accessory attachment; or that has been modified, disassembled, or reassembled by anyone other than AirTest. AirTest 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.

3. AirTest 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.

CO_2 Engine™ Error Codes And Recommended Action

Bit #	Error code	Error description	Suggested action
0	N/A	**Fatal Error**	Try to restart sensor by power OFF/ON.
1	2	**Reserved**	
2	4	**Algorithm Error**. Indicate wrong EEPROM configuration.	Try to restart sensor by power OFF/ON. Check detailed settings and configuration with software tools..
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.
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** Non-fatal error during memory operations.	Check detailed settings and configuration with software tools.
7	128	**Warm Up state** 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.

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 defective, 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!*

CO_2 Engine™ - Default Technical Specification

General Performance:

Storage Temperature Range	-30 to +70 °C
Sensor Life Expectancy	> 15 years
Maintenance Interval [1]	no maintenance required
Self-Diagnostics	complete function check of the sensor module
Operating Temperature Range	0 - 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]
Warm-up Time	<1 min. (@ full specs <15 minutes)
Conformance with the standards	Emission: EN61000-6-3:2001, EN55011B Immunity: EN61000-4-3, -4-11

Electrical / Mechanical:

Power Input [3]	5,7-7,5 VDC, stabilized to within 10% (external protection circuits required)
Current Consumption	40 mA average < 150 mA peak current (averaged during IR lamp ON, 100 msec) < 400 mA peak power (during IR lamp start-up, the first 25 msec)
Electrical Connections [4]	terminals not mounted (G+, G0, OUT1, OUT2, ErrStat, TxD, RxD, R/T)
Dimensions	5,1 x 5,7 x 2 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 ($T_{1/e}$)	< 3 minutes diffusion time
Measurement Range	0 - 2 000 $ppm_{vol.}$
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	Din3 switch input to trigger Background Calibration @ 400 ppm CO_2 Din4 switch input to trigger Zero Calibration @ 0 ppm CO_2

Linear Signal Outputs: [4]

Linear Conversion Range	1 -4 VDC for 0 - 2 000 $ppm_{vol.}$, with 0,5 VDC used as FAULT status signal
D/A Conversion Accuracy	± 1 % of reading ± 20 mV
OUT1 D/A Resolution	10 mV
Electrical Characteristics [5]	R_{OUT} < 100 W, R_{LOAD} > 5 kW , Power input > 6,5 V
OUT2 D/A Resolution	4,3 mV
Electrical Characteristics	R_{OUT} ~ 400 W, C_{LOAD} < 10pF, R_{LOAD} > 5 kW (R_{LOAD} > 500 kW w/o compensation)

UART Serial com port [4]

Protocol	Proprietary protocol (MODBUS open protocol is also available)
Hardware interface	CMOS UART with RxD, TxD (plus R/T to support RS485 standard drivers)
Baud Rate	9600 (maximum 19200)

Note 1: In normal IAQ and ventilation applications. accuracy is defined after minimum 3 weeks of continuous operation. However, some industrial applications may require periodic maintenance. Please, contact AirTest for further information!
Note 2: SO_2 enriched environments are excluded.
Note 3: Power inputs 12,5-14,0 VDC are possible (with resulting higher total power consumption and module heat dissipation) and is required if a 0-10 VDC output range is requested. 15,0 VDC is the absolute maximum input voltage allowed.
Note 4: Different options exist and can be customized depending on the application. Please, contact AirTest for further information!
Note 5: For the buffered output OUT1 the maximum output voltage range equals power voltage input minus 2,5 V