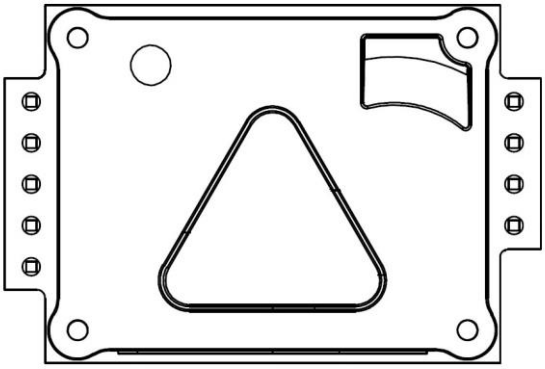
Honeywell

Commercial CO_2 Sensor CRIR E1
User Manual

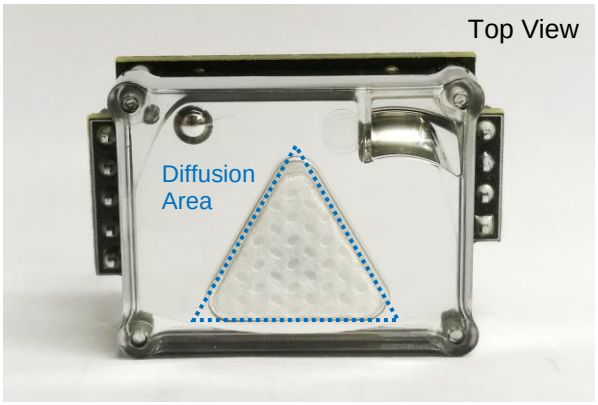


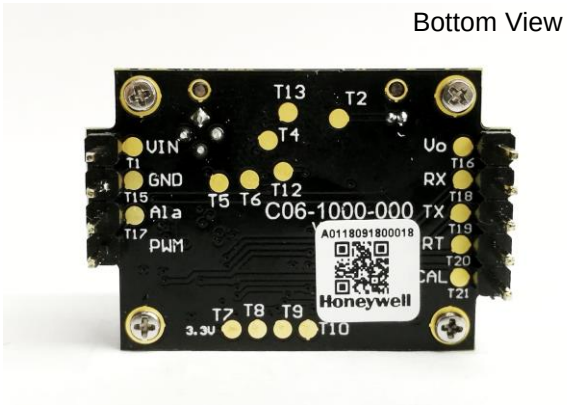
C06-0800-000

CONTENTS

1. Sensor Appearance

The CO_2 sensor PCB is black, and the optical chamber is silver. Gas diffuses in the sensor through the triangle area covered by a white PTFE membrane on the top of the sensor. Make sure that the gas diffusion area is not blocked or contaminated.





2. Handling

The CO_2 sensor should be handled by holding the PCB only. Under no circumstances should any force be applied to the optical chamber, which can affect the sensor performance and may permanently damage the sensor.

The CO_2 sensor is an electrostatic-sensitive device. Do NOT touch the sensor with bare hands. Make sure that the operator uses electrostatic dissipative gloves.

Any chances of exposing the CO_2 sensor to the following gases should be avoided, as they can deteriorate the sensor performance.

(1) Acidic gases, including HCl, HF, H_2S, SO_2, NO_x, etc.

(2) Basic gases, including NH_3, PH_3, N_2H_4, etc.

(3) Strong oxidizing gases, including Cl_2, F_2, O_3, H_2O_2, etc.

To extend the sensor lifetime, the CO_2 sensor should also be prevented from contacting salt spray, oil mist, soot and high humidity.

3. Automatic Baseline Correction (ABC)

Thanks to the built-in self-correcting Automatic Baseline Correction (ABC) algorithm, the CO_2 sensor features free maintenance in normal indoor environments. This algorithm automatically calibrates the sensor's lowest

reading over preconfigured time interval to 400 ppm CO_2, the expected CO_2 concentration in fresh air, thus compensating the sensor drift.

If the sensor measures CO_2 below 380 ppm continuously for more than 12 minutes, the Speedy Automatic Baseline Calibration (SABC) will be activated automatically to calibrate the lowest CO_2 reading in the last 12 minutes to 400 ppm. The SABC function quickly recovers the CO_2 sensor in the case that it has drifted severely to show too low readings.

Table 1 lists the ABC and SABC period specifications. Please refer to Section 8 Modbus Function Description for setting ABC period.

Table 1. ABC and SABC Period Specification

	Specification
ABC periods(1)	4-4800 hours (default: 180 hours)
SABC periods	12 min

(1) ABC periods can be configured per user's requirements. The available range is 4-4800 hours, and it must be the integer multiple of 4.

Note that exposing the CO_2 sensor to CO_2 concentrations below 400 ppm may result in incorrect operation of ABC algorithm and shall be avoided when the ABC function is ON. For how to switch the ABC function on/off, please refer to Section 8 Modbus Function Description.

4. Terminals Description

Table 2 specifies terminals and I/O options dedicated to Honeywell commercial CO_2 Sensor CRIR E1.

Table 2. Terminals Description

Pin No.	**Pin Function**	**Pin Description/Parameter Description**	**Electronical Specification**
Power Pins			
8	**GND**	Power supply minus terminal Sensor's reference (ground) terminal	
9	**Vin**	Power supply plus terminal Operation voltage range	Unprotected against reverse connection 4.5 V to 5.5 V
Communication Pins			
2	**UART_RxD**	UART data receive line configured as digital output Absolute max voltage range (1) Internal pull up to VDD(2) resistor Output low level (1)	no internal protection pulled up to VDD(2) at processor reset (power up and power down) GND - 0.3 V to VDD(2) + 0.5 V 120 k -0.3 V to 0.75 V

		Output high level (1)	2.3 V to VDD(2) + 0.3 V
3	**UART_TxD**	UART data transmission line configured as digital output Absolute max voltage range (1) Internal pull up to VDD(2) resistor Output low level (1) Output high level (1)	no internal protection pulled up to VDD(2) at processor reset (power up and power down) GND - 0.3 V to VDD(2) + 0.5 V 120 k 0.75 VDC max at 10 mA sink 2.4 VDC at 2 mA source
4	**UART_R/T**	Direction control line for half duplex, RS485 transceiver like MAX 485 configured as digital output Absolute max voltage range(1) Internal pull down to GND resistor Output low level (1) Output high level (1)	No internal protection, pulled down at processor reset (power up and power down) GND - 0.3 V to VDD(2) + 0.5 V 120 k 0.75 VDC max at 10 mA sink 2.4 VDC at 2 mA source
Input /Output			
1	**DAC**	DAC output configured as analog output used for direct reading by customer's microcontroller or to provide analog output. Normal concentration range Normal voltage range Voltage accuracy	No internal protection, pulled down at processor reset (power up and power down) 400 - 2000 ppm 0.4 V - 0.05 V to 2 V - 0.1 V ± 2 mV
5	**bCAL_in / CAL**	Digital input forcing background or zero calibration. **Background calibration** when closed for minimum 4, max 8 seconds, bCAL (background calibration) assuming 400 ppm CO_2 exposure. **Zero calibration:** when closed for minimum 16 seconds, CAL (zero calibration) assuming 0 ppm CO_2 exposure. Absolute max voltage range(1) Internal pull down to GND resistor output low level (1) output high level (1)	No internal protection, pulled up to VDD(2) at processor reset (power up and power down) GND - 0.3 V to VDD(2) + 0.5 V 120 k -0.3 V to 0.75 V 2.3 V to VDD(2) + 0.3 V

6	**PWM 1 kHz**	PWM output configured as digital output used for direct reading by customer's microcontroller or to provide analog output. Duty cycle min Duty cycle max PWM resolution PWM period Absolute max voltage range(1) Internal pull down to GND resistor output low level (1) output high level(1)	No internal protection, pulled down at processor reset (power up and power down) 0%, output Low 100%, output High 0.5 us ± 4% 1 ms ± 4% GND - 0.3 V to VDD(2) + 0.5 V 120 k 0.75 VDC max at 10 mA sink 2.4 VDC at 2 mA source
7	**Alarm_OC**	Open Collector output for alarm indication Absolute max voltage range (1) Internal pull up to G+ resistor Max sink current (1) Saturation voltage (1)	No internal protection, pulled up to G+ at processor reset (power up and power down) GND - 0.3 V to 5 V + 0.5 V 120 k 100 mA 2.3 V to Vin + 0.3 V

(1) Specified parameter relies on specification of subcontractor and is not tested by Honeywell.
(2) The nominal value of VDD is 3.3 V

5. Calibration

With the ABC function on, the sensor readings, which may have been drifted due to mishandling during transportation and/or installation, can be gradually recalibrated to the correct numbers. However, in the case that the user cannot wait for several cycles of ABC to run, the two following quick manual calibration can be performed.

5.1 CAL_in Pin Calibration

Two types of CAL_in Pin calibration are offered, bCAL (background calibration) which requires that the sensor is exposed to fresh air (400 ppm CO_2) and CAL (zero calibration) which requires the sensor cell to be completely immersed in CO_2-free atmosphere. A switch input is defined for the operator or master system to select one of the two prepared calibration codes (see Table 3). It is recommended that the sensor should be exposed to the targeted gas atmosphere for at least 10 mins to ensure the CO_2 concentration inside the sensor chamber is stable at the targeted value.

Table 3. Default Settings of bCAL-in and CAL-in

Input	Default Function
bCAL_in	Available when closed for minimum 4, max 8 seconds

	bCAL assuming 400 ppm CO_2 sensor exposure
CAL_in	Available when closed for minimum 16 seconds CAL assuming 0 ppm CO_2 sensor exposure

5.2 Modbus Calibration

Two types of Modbus calibration are offered, background calibration which requires that the sensor is exposed to fresh air (400 ppm CO_2) and 2nd point calibration which requires that the sensor is exposed to a certain atmosphere with a steady CO_2 concentration other than 400 ppm and this CO_2 concentration should be informed via Modbus communication to the sensor. For more details about the Modbus address and parameters configuration for user calibration, please refer to Section 8 Modbus Function Description.

6. Self-diagnostics

The CO_2 sensor has several built-in self-diagnostic functions. A full system check runs automatically every time when the power is turned on. Moreover, the sensor probes are checked against failure constantly during operation by checking the valid dynamic measurement ranges. All flash updates, initiated by the sensor itself or external connections, are checked by subsequent memory read back and data comparisons. These different system checks return error bytes to the system RAM. The full error codes are available from the UART port communication. Out of Range error is reset automatically after the CO_2 readings return to the normal measuring range. Memory error can be reset by power off/on. After the reset of memory error, it is recommended to check the settings stored in the memory to ensure they are the desired values.

7. Modbus Register Define

7.1 Input Registers Define

Table 4. Input Registers

IR#	#	Name	
IR1	0		Reserved
IR2	1		Reserved
IR3	2		Reserved
IR4	3		Reserved
IR5	4	Temperature	Detector Temperature
IR6	5	Meter Status	DI 1 – Reserved(1) DI 2 - Reserved(1) DI 3 - Reserved(1) DI 4 - Reserved(1) DI 5 - Reserved(1) DI 6 - Out of range DI 7 - Memory error DI 8 – Reserved(1)
IR7	6	Output Status	DI 1 - Alarm Output status (inverted due to Open Collector) DI 2 - PWM Output status (1 means full output)
IR8	7	Space CO_2	Space CO_2
IR9	8	PWM Output(2)	PWM Output(2)
IR10	9	Sensor Type ID High(3)	Sensor Type ID High(3)
IR11	10	Sensor Type ID Low(3)	Sensor Type ID Low(3)
IR12	11	Memory Map version	Memory Map version
IR13	12	FW version Main.Sub(4)	FW version Main.Sub(4)
IR14	13	Sensor ID High(5)	Sensor ID High(5)
IR15	14	Sensor ID Low(5)	Sensor ID Low(5)
IR16	15	Serial Num.1	Serial Num.1, Corresponding to the ASCII red 2-digit code.

			Default: ASCII 000-0000-000
IR17	16	Serial Num.2	Serial Num.2, Corresponding to the ASCII red 2-digit code. Default: ASCII 000-0000-000
IR18	17	Serial Num.3	Serial Num.3, Corresponding to the ASCII red 2-digit code. Default: ASCII 000-0000-000
IR19	18	Serial Num.4	Serial Num.4, Corresponding to the ASCII red 2-digit code. Default: ASCII 000-0000-000
IR20	19	Serial Num.5	Serial Num.5, Corresponding to the ASCII red 2-digit code. Default: ASCII 000-0000-000
IR21	20		Reserved
IR22	21		Reserved
IR23	22		Reserved
IR24	23		Reserved
IR25	24		Reserved
IR26	25		Reserved
IR27	26		Reserved
IR28	27		Reserved
IR29	28		Reserved
IR30	29		Reserved
IR31	30		Reserved
IR32	31		Reserved

(1) Reserved DIs returns 0.
(2) 0x3FFF represents 100% output, i.e. 2000 ppm CO_2
(3) IR10 low byte + IR11 contains Sensor Type ID 3-bytes value.
(4) IR13 high byte is FW Main revision, low byte – FW Sub revision.
(5) IR14 + IR15– 4-bytes Sensor's Serial Number.

7.2 Holding Registers Define

Table 5. Holding Registers

HR#	#	Name		
HR1	0		Reserved	
HR2	1		Reserved	
HR3	2		Reserved	
HR4	3		Reserved	
HR5	4	ABC Period	ABC Period in hours(8) default: 180 h	
HR6	5	User Acknowledgement Register	CI 1 - CO_2 random calibration point has been performed 0X0000 CI 2 - Reserved(6) CI 3 - Reserved(6) CI 4 - Reserved(6) CI 5 - Reserved(6) CI 6 - Reserved(6) CI 7 - Reserved(6) CI 8 - Reserved(6) CI 9 - Reserved(6) CI 10 - Reserved(6) CI 11 - Reserved(6) CI 12 - Reserved(6) CI 13 - Reserved(6) CI 14 - Reserved(6) CI 15 - Reserved(6) CI 16 - Reserved(6)	
HR7	6	User Special Command Register(7)	Command	Parameter
			0x7C	0x1 - CO_2 random calibration
HR8	7	User Concentration	User concentration. (default: 400 ppm)	

HR9	8		Reserved, returns "illegal data address" exception
HR10	9		Reserved, returns "illegal data address" exception
HR11	10		Reserved, returns "illegal data address" exception
HR12	11		Reserved, returns "illegal data address" exception
HR13	12		Reserved, returns "illegal data address" exception
HR14	13		Reserved, returns "illegal data address" exception
HR15	14		Reserved, returns "illegal data address" exception
HR16	15		Reserved, returns "illegal data address" exception
HR17	16		Reserved, returns "illegal data address" exception
HR18	17		Reserved, returns "illegal data address" exception
HR19	18		Reserved, returns "illegal data address" exception
HR20	19		Reserved, returns "illegal data address" exception
HR21	20		Reserved, returns "illegal data address" exception
HR22	21		Reserved, returns "illegal data address" exception
HR23	22		Reserved, returns "illegal data address" exception
HR24	23		Reserved, returns "illegal data address" exception
HR25	24		Reserved, returns "illegal data address" exception
HR26	25		Reserved, returns "illegal data address" exception
HR27	26		Reserved, returns "illegal data address" exception
HR28	27		Reserved, returns "illegal data address" exception
HR29	28		Reserved, returns "illegal data address" exception
HR30	29		Reserved
HR31	30		Reserved
HR32	31		Reserved

(6) Reserved CIs returns 0.
(7) Special Command Register is write-only.
(8) Writing ABC_Period zero value suspends ABC function, but ABC samples and ABC time counting do not lose. To resume ABC function with prior ABC samples and ABC time, write ABC_Period non-zero values.

8. Modbus Function Description

The serial port configuration is: 9600, 8, 1, N, N. The sensor is addressed as “Any address” (0xFE).

8.1 Input Registers Description

Values are read from IR using “Read input registers” (function code 04).

8.1.1 Read Detector Temperature

Master Transmit:
<FE> <04> <00> <04> <00> <01> <64> <04>
Slave Reply:
<FE> <04> <02> <30> <D4> <51> <9A>
Data Explain：
<30> <D4> is valid data 0x30D4, decimal is 12500. After conversion (divided by 100 first, then subtract 100), it is 25 degrees Celsius. Note that the detector temperature is usually higher than the ambient temperature.

8.1.2 Read Meter Status

Master Transmit:
<FE> <04> <00> <05> <00> <01> <35> <C4>
Slave Reply:
<FE> <04> <02> <01> <60> <AC> <9C>
Data Explain：
<01> <60> is valid data 0x0160, the binary is 0b101100000, the 0th bit of the data bit is DI1, the 1st bit of the data bit is DI2, and so on. The valid bits are as follows:
DI 6 - Out of Range
DI 7 - Memory error

8.1.3 Read Output Status

Master Transmit:
<FE> <04> <00> <06> <00> <01> <C5 > <C4>
Slave Reply:
<FE> <04> <02> <00> <03> <ED> <25>
Data Explain：
<00> <03> is valid data 0x0003, the binary is 0b11. The valid bits are as follows:
DI 1 - Alarm Output status (inverted due to Open Collector)
DI 2 - PWM Output status (1 means full output)

8.1.4 Read Space CO_2

Master Transmit:
<FE> <04> <00> <07> <00> <01> <94 > <04>
Slave Reply:
<FE> <04> <02> <01> <90> <AC> <D8>
Data Explain：
<01> <90> is valid data 0x0190, decimal is 400 ppm.

8.1.5 Read PWM Output

Master Transmit:
<FE> <04> <00> <08> <00> <01> <A4 > <07>
Slave Reply:
<FE> <04> <02> <3F> <FF> <FC> <94>
Data Explain：
<3F> <FF> is valid data 0x3FFF, it represents 100% output, i.e. 2000 ppm CO_2.

8.1.6 Read Sensor Type ID

Master Transmit:
<FE> <04> <00> <09> <00> <02> <B5> <C6>
Slave Reply:
<FE> <04> <04> <00> <00> <18> <00> <FE> <8B>
Data Explain：
<00> <00> <18> <00> is valid data 0x00001800, IR09 low byte + IR10 contains Sensor Type ID 3-bytes value, so this data is 0x001800, it indicates the type of sensor.

8.1.7 Read Memory Map Version

Master Transmit:
<FE> <04> <00> <0B> <00> <01> <54 > <07>
Slave Reply:
<FE> <04> <02> <41> <01> <5C> <B4>
Data Explain：
<41> <01> is valid data 0x4101, it indicates memory map version.

8.1.8 Read FW Version Main and Sub.

Master Transmit:
<FE> <04> <00> <0C> <00> <01> <E5 > <C6>
Slave Reply:
<FE> <04> <02> <01> <00> <AC> <B4>
Data Explain：

<01> <00> is valid data 0x0100, IR13 high byte is FW Main revision, low byte – FW Sub revision. So this version of FW is 1.0

8.1.9 Read Sensor ID

Master Transmit:
<FE> <04> <00> <0D> <00> <02> <F4 > <07>
Slave Reply:
<FE> <04> <04> <11> <03> <30> <33> <55> <A2>
Data Explain：
<11> <03> <30> <33>is valid data 0x11033033, it means sensor ID.

8.1.10 Read Serial Number

Master Transmit:
<FE> <04> <00> <0F> <00> <05> <14 > <05>
Slave Reply:
<FE> <04> <0A> <53> <43> <30> <37> <31> <31> <30><33><30><33><C4><D6>
Data Explain：
<53> <43> <30> <37> <31> <31> <30><33><30><33> is valid data 0x53433037313130333033. After conversion to ASCII, it is SC07110303.

8.2 Holding Registers Description

Values are read and written from IR using “Read holding registers” (function code 03).

8.2.1 Setup ABC Period

Master Transmit:
<FE> <06> <00> <04> <00> <B4> <DC > <73>
Slave Reply:
<FE> <06> <00> <04> <00> <B4> <DC > <73>
Data Explain：
<00> <B4> is valid data 0x00B4, decimal is 180. It means ABC calibration (a program for automatic calibration) is performed every 180 hours. The value range is (4, 4800) hours and should be an integer multiple of 4. When the value is 0, this function is disabled.

8.2.2 Read ABC Period

Master Transmit:
<FE> <03> <00> <04> <00> <01> <D1 > <C4>
Slave Reply:
<FE> <03> <02> <00> <B4> <AC> <27>
Data Explain：
<00> <B4> is valid data 0x00B4, decimal is 180 hours.

8.2.3 Setup User Concentration

Master Transmit:
<FE> <06> <00> <07> <01> <90> <2D > <F8>
Slave Reply:
<FE> <06> <00> <07> <01> <90> <2D > <F8>
Data Explain：
<01> <90> is valid data 0x0190, decimal is 400ppm. It means the user calibration concentration is set to 400ppm.
<2D> <F8> is CRC and should be calculated based on the user calibration concentration value.

8.2.4 Read User Concentration

Master Transmit:
<FE> <03> <00> <07> <00> <01> <21 > <C4>
Slave Reply:
<FE> <03> <02> <01> <90> <AD> <AC>
Data Explain：
<01> <90> is valid data 0x0190, decimal is 400ppm.

8.2.5 Setup User Acknowledgement

Master Transmit:

<FE> <06> <00> <05> <00> <00> <8D > <C4>
Slave Reply:
<FE> <06> <00> <05> <00> <00> <8D > <C4>
Data Explain：
<00> <00> is valid data 0x0000, it means to clear the calibration completion flag.

8.2.6 Setup User Special Command
Master Transmit:
<FE> <06> <00> <06> <7C> <01> <9C > <C4>
Slave Reply:
<FE> <06> <00> <06> <7C> <01> <9C > <C4>
Data Explain：
<7C> <01> is valid data 0x7C01, it means to start user calibration.

8.2.7 read User Acknowledgement
Master Transmit:
<FE> <03> <00> <05> <00> <01> <80> <04>
Slave Reply:
<FE> <03> <02> <00> <01> <AC> <50>
Data Explain：
<00> <01> is valid data 0x0001, it means that the user calibration completion flag has been set to 1, indicating that the user calibration has been completed.

For the user calibration process, please use the instructions of 8.2.3 to 8.2.7 in order.