UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Escola Superior d'Enginyeries Industrial,
Aeroespacial i Audiovisual de Terrassa

Desenvolupament d'un sistema de monitoratge de la qualitat de l'aire en el transport públic

Document:

Annexos

Autor/Autora:

Tarek Alrifai Alhamad

Director:

Daniel Garcia Almiñana

Titulació:

Màster en Enginyeria Industrial

Convocatòria:

Juliol 2022

TREBALL DE FI D'ESTUDIS

ÍNDEX

1 Taules d'especificacions tècniques

Els següents apartats recullen les taules resum de les especificacions tècniques que facilita el fabricant de cada component que es considera durant el projecte, a més, s'afegeix l'enllaç per a consultar el document original d'especificacions on s'ha consultat.

1.1 Plataformes de processament

1.1.1 Raspberry Pi 3

Specifications

Processor:	Broadcom BCM2837B0, Cortex-A53 64-bit SoC @ 1.4GHz
Memory:	1GB LPDDR2 SDRAM
Connectivity:	■ 2.4GHz and 5GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.2, BLE ■ Gigabit Ethernet over USB 2.0 (maximum throughput 300Mbps) ■ 4 × USB 2.0 ports
Access:	Extended 40-pin GPIO header
Video & sound:	■ 1 × full size HDMI ■ MIPI DSI display port ■ MIPI CSI camera port ■ 4 pole stereo output and composite video port
Multimedia:	H.264, MPEG-4 decode (1080p30); H.264 encode (1080p30); OpenGL ES 1.1, 2.0 graphics
SD card support:	Micro SD format for loading operating system and data storage
Input power:	■ 5V/2.5A DC via micro USB connector ■ 5V DC via GPIO header ■ Power over Ethernet (PoE)–enabled (requires separate PoE HAT)
Environment:	Operating temperature, 0–50°C
Compliance:	For a full list of local and regional product approvals, please visit www.raspberrypi.org/products/raspberry-pi-3-model-b+
Production lifetime:	The Raspberry Pi 3 Model B+ will remain in production until at least January 2023.

Enllaç de consulta: https://static.raspberrypi.org/files/product-briefs/Raspberry-Pi-Model-Bplus-Product-Brief.pdf

1.1.2 Beaglebone Blue

Processor: Octavo Systems OSD3358 1GHz ARM® Cortex-A8

- 512MB DDR3 RAM
- 4GB 8-bit on-board flash storage
- 2×32-bit 200-MHz programmable real-time units (PRUs)
- On-board flash programmed with Linux distribution

Connectivity and sensors

- Battery: 2-cell LiPo support with balancing, 6-16V charger input
- Wireless: 802.11bgn, Bluetooth 4.1 and BLE
- Motor control: 8 6V servo out, 4 DC motor out, 4 quad enc in
- Sensors: 9 axis IMU, barometer
- Connectivity: HighSpeed USB 2.0 client and host
- Other easy connect interfaces: GPS, DSM2 radio, UARTs, SPI, I2C, analog, buttons, LEDs

Software Compatibility

- Debian, ROS, Ardupilot, ...
- Graphical programming, Cloud9 IDE on Node.js
- plus much more

Enllaç de consulta: https://www.mouser.es/pdfdocs/BeagleBone_Blue_ShortSpec11-3.pdf

1.1.3 Arduino Unoi

Features

- **ATMega328P** Processor
  - **Memory**
    - AVR CPU at up to 16 MHz
    - 32KB Flash
    - 2KB SRAM
    - 1KB EEPROM
  - **Security**
    - Power On Reset (POR)
    - Brown Out Detection (BOD)
  - **Peripherals**
    - 2x 8-bit Timer/Counter with a dedicated period register and compare channels
    - 1x 16-bit Timer/Counter with a dedicated period register, input capture and compare channels
    - 1x USART with fractional baud rate generator and start-of-frame detection
    - 1x controller/peripheral Serial Peripheral Interface (SPI)
    - 1x Dual mode controller/peripheral I2C
    - 1x Analog Comparator (AC) with a scalable reference input
    - Watchdog Timer with separate on-chip oscillator
    - Six PWM channels
    - Interrupt and wake-up on pin change
  - **ATMega16U2 Processor**
    - 8-bit AVR® RISC-based microcontroller
  - **Memory**
    - 16 KB ISP Flash
    - 512B EEPROM
    - 512B SRAM
    - debugWIRE interface for on-chip debugging and programming
  - **Power**
    - 2.7-5.5 volts

Enllaç de consulta: https://docs.arduino.cc/resources/datasheets/A000066-datasheet.pdf

1.1.4 Arduino Due

Tech specs

MICROCONTROLLER	AT91SAM3X8E
OPERATING VOLTAGE	3.3V
INPUT VOLTAGE (RECOMMENDED)	7-12V
INPUT VOLTAGE (LIMITS)	6-16V
DIGITAL I/O PINS	54 (of which 12 provide PWM output)
ANALOG INPUT PINS	12
ANALOG OUTPUT PINS	2 (DAC)
TOTAL DC OUTPUT CURRENT ON ALL I/O LINES	130 mA
DC CURRENT FOR 3.3V PIN	800 mA
DC CURRENT FOR 5V PIN	800 mA
FLASH MEMORY	512 KB all available for the user applications
SRAM	96 KB (two banks: 64KB and 32KB)
CLOCK SPEED	84 MHz
LENGTH	101.52 mm
WIDTH	53.3 mm
WEIGHT	36 g

Enllaç de consulta: https://store.arduino.cc/collections/boards/products/arduino-due

1.1.5 Arduino Mega

Features

- **ATmega2560 Processor**
  - Up to 16 MIPS Throughput at 16MHz
  - 256k bytes (of which 8k is used for the bootloader)
  - 4k bytes EEPROM
  - 8k bytes Internal SRAM
  - 32 × 8 General Purpose Working Registers
  - Real Time Counter with Separate Oscillator
  - Four 8-bit PWM Channels
  - Four Programmable Serial USART
  - Controller/Peripheral SPI Serial Interface
- **ATmega16U2**
  - Up to 16 MIPS Throughput at 16 MHz
  - 16k bytes ISP Flash Memory
  - 512 bytes EEPROM
  - 512 bytes SRAM
  - USART with SPI master only mode and hardware flow control (RTS/CTS)
  - Master/Slave SPI Serial Interface
- **Sleep Modes**
  - Idle
  - ADC Noise Reduction
  - Power-save
  - Power-down
  - Standby
  - Extended Standby
- **Power**
  - USB Connection
  - External AC/DC Adapter
- **I/O**
  - 54 Digital
  - 16 Analog
  - 15 PWM Output

Enllaç de consulta:
https://docs.arduino.cc/static/9050ae718d6cda559d88f1cfdb20ba0d/A000067-datasheet.pdf

1.2 Sensors

1.2.1 EE850

Technical Data

Measurands

CO_2		
Measurement principle	dual wavelength non-dispersive infrared technology (NDIR)	
Measuring range	0...2000 / 5000 / 10000 ppm	
Accuracy at 25 °C (77 °F) and 1013 mbar (14.7 psi)	0...2000 ppm:	< ± (50 ppm +2% of measured value)
	0...5000 ppm:	< ± (50 ppm +3% of measured value)
	0...10000 ppm:	< ± (100 ppm +5% of measured value)
Response time t_{63}	< 100 seconds at 3 m/s (590 ft/min) air speed in the duct	
Temperature dependency, typ.	± (1 + CO_2 concentration [ppm] / 1000) ppm/°C, for -20...45 °C (-4...113 °F)	
Calibration interval 1)	> 5 years	
Measuring interval	approx. 15 seconds	
Temperature		
Working range	-20...60 °C (-4...140 °F)	
Accuracy at 20 °C (68 °F)	±0.3 °C (±0.54 °F)	
Response time t_{63}	< 50 seconds	
Relative Humidity		
Working range	0...95 % RH	
Accuracy at 20 °C (68 °F)	± 3 % RH (20...80 % RH)	
Response time t_{63}	< 10 seconds	

Outputs

Analogue		
CO_2: 0...2000 / 5000 / 10000 ppm	0-5 V / 0-10 V	-1 mA < I_L < 1 mA
	4-20 mA	R_L < 500 Ohm
T scale: according ordering guide **RH** scale: 0...100 % RH	0 - 5 V / 0 - 10 V	-1 mA < I_L < 1 mA
Digital Interface	RS485 with max. 32 devices on one bus	
Protocol	Modbus RTU or BACnet MS/TP	
Passive temperature, 2-wire	T sensor type according ordering guide	
Wire resistance (terminal - sensor), typ.	0.4 Ohm	

General

Power supply class III	24 V AC ± 20 %	15-35 V DC
Current consumption, typ.	typ. 15 mA + output current	
Current peak, max.	350 mA for 0.3 seconds (analogue output)	
	150 mA for 0.3 seconds (RS485 interface)	
Minimum air speed in the duct	1 m/s (196 ft/min)	
Enclosure material	polycarbonate, UL94V-0 approved	
Protection class	enclosure: IP65 / NEMA 4	
	probe: IP20	
Cable gland	M16 x 1.5	
Electrical connection	screw terminals max. 2.5 mm² (AWG 14)	
Electromagnetic compatibility	EN61326-1 EN61326-2-3 Industrial Environment	CE
	FCC Part 15 ICES-003 ClassB	
Working and storage conditions	-20...60 °C (-4...140 °F)	0...95 % RH (non-condensing)

1) under normal operating conditions

Enllaç de consulta: https://www.sensovant.com/productos/pdf/gases/datasheett_ee850.pdf

1.2.2 EE893

Technical Data

Measured values

CO_2

Measurement principle	Dual wavelength (non-dispersive infrared technology) NDIR	
Working range	0...2000 / 5000 / 10000 ppm	
Accuracy at 25 °C and 1013 mbar [1] (77 °F and 14.69 psi)	0...2000 ppm:	< ± (50ppm +2% of measuring value)
	0...5000 ppm:	< ± (50ppm +3% of measuring value)
	0...10000 ppm:	< ± (100ppm +5% of measuring value)
Response time t_{90}	105 s with measured data averaging (smooth output) 60 s without measured data averaging	
Temperature dependency	typ. ± (1 + CO_2 concentration [ppm] / 1000) ppm/°C (-20...45 °C) (-4...113 °F)	
Calibration interval [2]	>5 years	
Measuring time interval	adjustable from 15 s up to 1 h (factory setting: 15 s)	

General

Digital interface	E2 (details: www.epluse.com)
Supply voltage	4.75 - 7.5 V DC
Average power consumption [3]	58 µA (at 1 h measurement interval) ...3.7 mA (at 15 s measurement interval)
Peak current	see power consumption graph
Electrical connection	contact pins, edge card socket (e.g. type MEC1-108-2)
Working conditions	-40...60 °C (-40...140 °F) 0...95 % RH (not condensating) 85...110 kPa (12.33...15.95 psi)
Storage conditions	-40...60 °C (-40...140 °F) 0...95 % RH (not condensating) 70...110 kPa (10.15...15.95 psi)

1) for averaging output
2) under normal operating conditions
3) the average power consumption depends on the adjusted measuring time interval

Enllaç de consulta: https://www.instrumart.com/assets/EplusE-EE893-Datasheet.pdf

1.2.3 T6713

Telaire T6713 series CO_2 Module Specifications

Method
Non Dispersive Infrared (NDIR), gold plated optics, diffusion sampling (with Telaire's Patented ABC Logic Self Calibrated Algorithm)

Measurement Range (2)
0 to 5000 ppm

Dimensions
1.18in X 0.787in X 0.34in
(30mm X 15.6mm X 8.6mm)

Accuracy (1) (5)
400-5000 ppm +/- 30 ppm ± 3% of reading
400-2000 ppm +/- 25 ppm ± 3% of reading

Temperature Dependence
5 ppm per °C or 0.5% of the reading per °C, whichever is greater

Stability
< 2% of FS over life of sensor (15 years typical)

Pressure Dependence
0.13% of reading per mm Hg

Calibration Interval
Not required

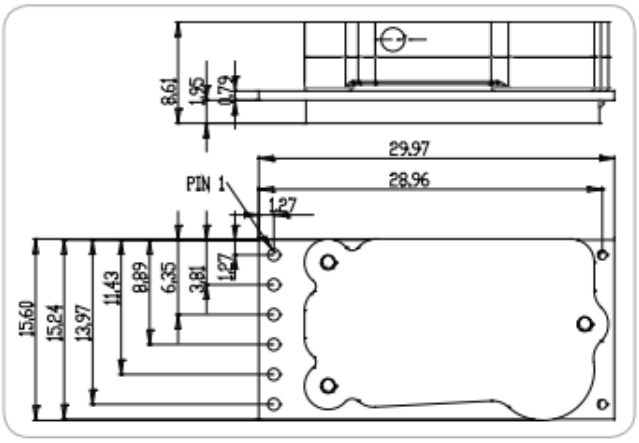
Response Time
< 3 minutes for 90% step change typical

Signal Update
Every 5 seconds

Warm Up Time
- < 2 minutes (operational)
- 10 minutes (maximum accuracy)

Operating Conditions
- 14°F to 140°F (-10°C to 60°C)
- 0 to 95% RH, non-condensing

Storage Conditions
-22°F to 158°F (-30°C to 70°C)



All dimensions in millimeters (mm)

Output

Digital (3)
I^2C slave up to 100kHz
UART @ 19200 Baud w/Modbus support

PWM Output Mode
Two options:
- Cycle period 1002 ms (~1Hz)
- 40 us (25kHz)

Power Supply Requirements (4)
- 4.5-5.5 VDC
- Peak 200mA (155mA typical)
- Average 25mA (20mA typical)

Interface Connections
Designed for six (6) pin male header with 0.1 in (2.54 mm) spacing. Header not included.

Notes:

(1) Tolerance based on span gas of ±2%, which adds to the uncertainty, tested at Standard Ambient Temperature and Pressure (SATP).

(2) Subjecting sensors to environments less than 400 ppm for more than 15 minutes may affect accuracy due to ABC Logic algorithm.

(3) Please call for detailed product specifications.

(4) Based on nominal 5VDC input voltage. For best performance, DC supply should be a regulated, low noise power source.

(5) The module may exhibit a tolerance addition of ±60ppm when first installed. This will be corrected by the ABC Logic in first weeks of operation.

Enllaç de consulta: https://www.farnell.com/datasheets/2578451.pdf

1.2.4 DHT22

3. Technical Specification:

Model	DHT22
Power supply	3.3-6V DC
Output signal	digital signal via single-bus
Sensing element	Polymer capacitor
Operating range	humidity 0-100%RH; temperature -40~80Celsius
Accuracy	humidity +-2%RH(Max +-5%RH); temperature <+-0.5Celsius
Resolution or sensitivity	humidity 0.1%RH; temperature 0.1Celsius
Repeatability	humidity +-1%RH; temperature +-0.2Celsius
Humidity hysteresis	+-0.3%RH
Long-term Stability	+-0.5%RH/year
Sensing period	Average: 2s
Interchangeability	fully interchangeable
Dimensions	small size 14*18*5.5mm; big size 22*28*5mm

Enllaç de consulta: https://www.sparkfun.com/datasheets/Sensors/Temperature/DHT22.pdf

1.2.5 DHT11

Parameters	Conditions	Minimum	Typical	Maximum
Humidity				
Resolution		1%RH	1%RH	1%RH
			8 Bit	
Repeatability			±1%RH	
Accuracy	25℃		±4%RH	
	0-50℃			±5%RH
Interchangeability	Fully Interchangeable			
Measurement Range	0℃	30%RH		90%RH
	25℃	20%RH		90%RH
	50℃	20%RH		80%RH
Response Time (Seconds)	1/e(63%)25℃, 1m/s Air	6 S	10 S	15 S
Hysteresis			±1%RH	
Long-Term Stability	Typical		±1%RH/year	
Temperature				
Resolution		1℃	1℃	1℃
		8 Bit	8 Bit	8 Bit
Repeatability			±1℃	
Accuracy		±1℃		±2℃
Measurement Range		0℃		50℃
Response Time (Seconds)	1/e(63%)	6 S		30 S

Enllaç de consulta: https://www.mouser.com/datasheet/2/758/DHT11-Technical-Data-Sheet-Translated-Version-1143054.pdf

1.2.6 SHT21

Sensor Performance

Relative Humidity

Parameter	Condition	min	typ	max	Units
Resolution [1]	12 bit		0.04		%RH
	8 bit		0.7		%RH
Accuracy tolerance [2]	typ		±2.0		%RH
	max		see Figure 2		%RH
Repeatability			±0.1		%RH
Hysteresis			±1		%RH
Nonlinearity			<0.1		%RH
Response time [3]	τ 63%		8		s
Operating Range	extended [4]	0		100	%RH
Long Term Drift [5]	normal		< 0.5		%RH/yr

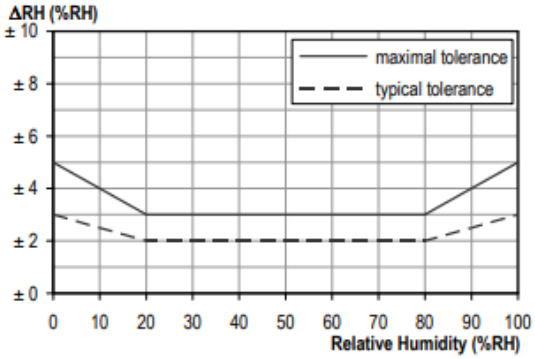


Figure 2 Typical and maximal tolerance at 25°C for relative humidity. For extensive information see Users Guide, Sect. 1.2.

Temperature

Parameter	Condition	min	typ	max	Units
Resolution [1]	14 bit		0.01		°C
	12 bit		0.04		°C
Accuracy tolerance [2]	typ		±0.3		°C
	max		see Figure 3		°C
Repeatability			±0.1		°C
Operating Range	extended [4]	-40		125	°C
Response Time [7]	τ 63%	5		30	s
Long Term Drift			< 0.04		°C/yr

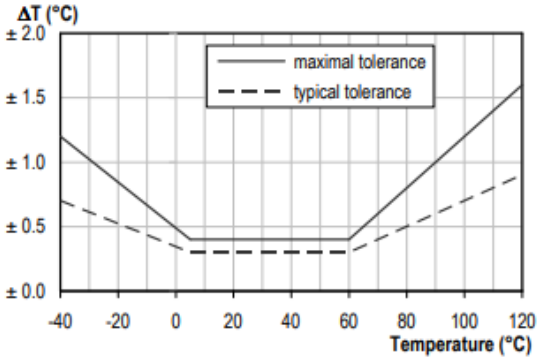


Figure 3 Typical and maximal tolerance for temperature sensor in °C.

Electrical Specification

Parameter	Condition	min	typ	max	Units
Supply Voltage, VDD		2.1	3.0	3.6	V
Supply Current, IDD [6]	sleep mode		0.15	0.4	µA
	measuring	200	300	330	µA
Power Dissipation [6]	sleep mode		0.5	1.2	µW
	measuring	0.6	0.9	1.0	mW
	average 8bit		3.2		µW
Heater	VDD = 3.0 V	5.5mW, ΔT = + 0.5-1.5°C			
Communication	digital 2-wire interface, I²C protocol				

Table 1 Electrical specification. For absolute maximum values see Section 4.1 of Users Guide.

Packaging Information

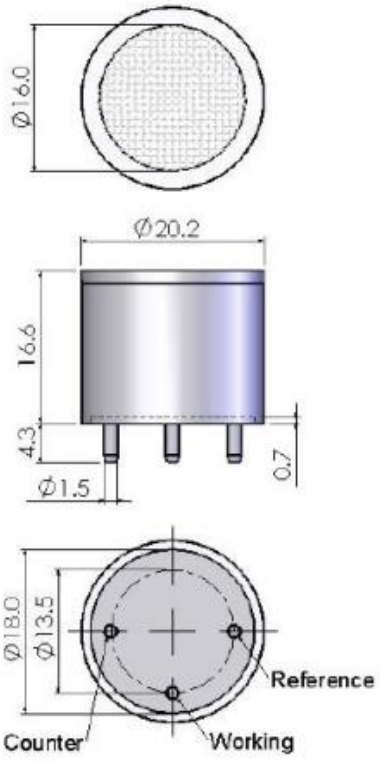
Sensor Type	Packaging	Quantity	Order Number
SHT21	Tape & Reel	400	1-100707-01
	Tape & Reel	1500	1-100645-01
	Tape & Reel	5000	1-100694-01

This datasheet is subject to change and may be amended without prior notice.

Enllaç de consulta: https://www.farnell.com/datasheets/1780639.pdf

1.2.7 4-so2-20

Outline Dimensions



All dimensions are in millimetres mm.
All tolerances are +/- 0.2mm.
Note: PCB sockets are recommended for the sensor pin connection. Soldering or using glue with the sensor should be avoided and will invalidate warranty.

SPECIFICATION – 4 SERIES

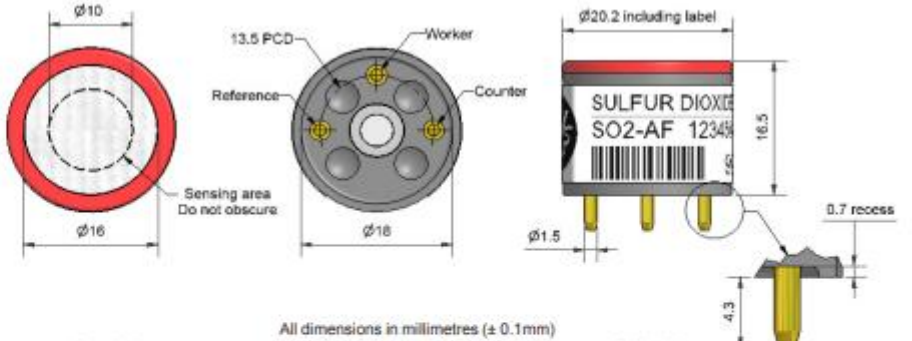
Operating Principle:	Electrochemical, 3-electrode cell
Gas Detected:	Sulphur Dioxide SO2
Measurement Range:	0 – 20 ppm
Maximum Overload:	150 ppm
Resolution:	0.1 ppm
Expected Operating Life:	2 years in air
Temperature Range:	-20ºC to +40ºC
Humidity Range (non-condensing):	15 – 90% RH
Response Time (T90):	≤ 45 seconds
Sensitivity:	0.5 +/- 0.1 µA/ppm
Long Term Sensitivity Drift:	< 2% signal per month
Linearity at Standard Range:	Linear
Baseline (20ºC):	< +/- 0.4 µA
Baseline Drift (-20ºC to 40ºC):	0 to 0.05 ppm SO2 equivalent
Pressure range:	90 to 111 kPa
Bias Potential:	0 mV
Warranty Period:	12 months from date of despatch
Storage Life:	6 months in original sealed container
Storage Temperature:	0ºC to +20ºC
Weight (approx):	5g
Orientation Sensitivity:	None
Part Number:	2112B0421400

Enllaç de consulta: https://euro-gasman.com/media/wysiwyg/Gas_Sensors/SO2/4_SO2_20.pdf

1.2.8 SO2-AF

Technical Specification

Figure 1 SO2-AF Schematic Diagram PATENTED



PERFORMANCE	Sensitivity	nA/ppm in 10ppm SO_2	300 to 550
	Response time	t_{90} (s) from zero to 10ppm SO_2	< 35
	Zero current	ppm equivalent in zero air	< ± 0.6
	Resolution	RMS noise (ppm equivalent)	< 0.1
	Range	ppm limit of performance warranty	50
	Linearity	ppm error at full scale, linear at zero and 10ppm	< ± 0.3
	Overgas limit	maximum ppm for stable response to gas pulse	75
LIFETIME	Zero drift	ppm equivalent change/year in lab air	<0.1
	Sensitivity drift	% change/year in lab air, monthly test	< 4
	Operating life	months until 80% original signal (24 month warranted)	> 24
ENVIRONMENTAL	Sensitivity @ -20°C	% (output @ -20°C/output @ 20°C) @ 10ppm	70 to 90
	Sensitivity @ 50°C	% (output @ 50°C/output @ 20°C) @ 10ppm	90 to 102
	Zero @ -20°C	ppm equivalent change from 20°C	< ± 0.8
	Zero @ 50°C	ppm equivalent change from 20°C	< ± 3
CROSS SENSITIVITY	Filter capacity	ppm·hrs	H_2S 1000
	H_2S sensitivity	% measured gas @ 20ppm	H_2S < 3
	NO_2 sensitivity	% measured gas @ 10ppm	NO_2 < -130
	Cl_2 sensitivity	% measured gas @ 10ppm	Cl_2 < -60
	NO sensitivity	% measured gas @ 50ppm	NO < ± 2
	CO sensitivity	% measured gas @ 400ppm	CO < 1.6
	H_2 sensitivity	% measured gas @ 400ppm	H_2 < 0.3
	C_2H_4 sensitivity	% measured gas @ 400ppm	C_2H_4 < 40
	NH_3 sensitivity	% measured gas @ 20ppm	NH_3 < 0.1
KEY SPECIFICATIONS	Temperature range	°C	-30 to 50
	Pressure range	kPa	80 to 120
	Humidity range	% rh continuous	15 to 90
	Storage period	months @ 3 to 20°C (stored in sealed pot)	6
	Load Resistor	Ω (recommended)	10 to 47
	Weight	g	< 6

At the end of the product's life, do not dispose of any electronic sensor, component or instrument in the domestic waste, but contact the instrument manufacturer, Alphasense or its distributor for disposal instructions.

NOTE: all sensors are tested at ambient environmental conditions, with 10 ohm load resistor, unless otherwise stated. As applications of use are outside our control, the information provided is given without legal responsibility. Customers should test under their own conditions, to ensure that the sensors are suitable for their own requirements.

Enllaç de consulta: https://www.alphasense.com/wp-content/uploads/2015/09/SO2AF.pdf

1.2.9 MQ136

SPECIFICATIONS

A. Standard work condition

Symbol	Parameter name	Technical condition	Remarks
Vc	Circuit voltage	5V±0.1	AC OR DC
V_H	Heating voltage	5V±0.1	ACOR DC
R_L	Load resistance	can adjust	
R_H	Heater resistance	31Ω ± 5%	Room Tem
P_H	Heating consumption	less than 800mw	

B. Environment condition

Symbol	Parameter name	Technical condition	Remarks
Tao	Using Tem	-10℃-45℃	
Tas	Storage Tem	-20℃-70℃	
R_H	Related humidity	less than 95%Rh	
O_2	Oxygen concentration	21%(standard condition)Oxygen concentration can affect sensitivity	minimum value is over 2%

C. Sensitivity characteristic

Symbol	Parameter name	Technical parameter	Ramark 2
Rs	Sensing Resistance	30KΩ-200KΩ (10ppm H_2S)	Detecting concentration scope : 1-100ppm H_2S
α (20/5) H_2S	Concentration Slope rate	≤ 0.65	
Standard Detecting Condition	Temp: 20℃ ± 2℃ Humidity: 65%± 5%	Vc:5V±0.1 Vh: 5V±0.1	
Preheat time	Over 24 hour		

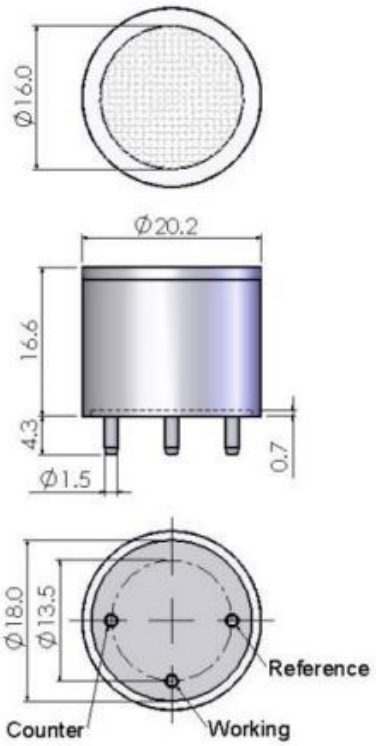
D. Structure and configuration, basic measuring circuit

Enllaç de consulta: http://www.sensorica.ru/pdf/MQ-136.pdf

1.2.10 4-NO2-20

4-NO2-20 NITROGEN DIOXIDE SENSOR 0-20PPM NO2

Outline Dimensions



SPECIFICATION – 4 SERIES

Operating Principle:	Electrochemical, 3-electrode cell
Gas Detected:	Nitrogen Dioxide NO2
Measurement Range:	0 – 20 ppm
Maximum Overload:	250 ppm
Resolution:	0.1 ppm
Expected Operating Life:	2 years in air
Temperature Range:	-20°C to +50°C
Humidity Range (non-condensing):	15 – 90% RH
Response Time (T90):	≤ 30 seconds
Long Term Sensitivity Drift:	< 2% signal per month
Linearity at Standard Range:	Linear
Sensitivity:	0.60 +/- 0.15 µA/ppm
Baseline (20°C):	± 0.4 µA
Baseline Drift (-20°C to 40°C):	0 to -0.5 ppm equivalent
Pressure range:	90 to 110 kPa
Bias Potential:	0 mV
Warranty Period:	12 months from date of despatch
Storage Life:	6 months in original sealed container
Storage Temperature:	0°C to +20°C
Weight (approx):	5 g
Orientation Sensitivity:	None
Part Number:	2112B0321400

Enllaç de consulta: https://euro-gasman.com/media/wysiwyg/Gas_Sensors/SOLIDSENSE/4_NO2_20.pdf

1.2.11 GSNT11

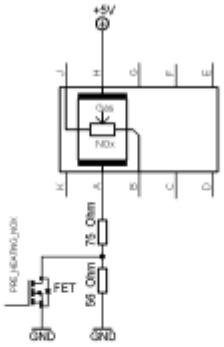
a. Characteristics

Index		Spec. & Test condition		
Circuit Voltage	Vc	Sensor input Voltage :1~12Volt, Sensor Resistance : refer to Rank table		
	VH	Heater input voltage : 5volt±1%, Heater Resistance : 33.0Ω±2.0Ω		
	PH	Power consumption : Less than 450㎽, Inrush current : Less than 200mA		
Characteristics of sensitivity (β) (Rs,gas / Rs,air)		NO_2 : 50ppm	1.80≤β≤1.83 Accuracy : ±15%	Accuracy : ±15%
Guarantee		- 3years - Calibration interval 1years recommended		
Operating environment		- Temp. : -10 ~ 50℃, Humidity : 5 ~ 90%RH, Non-condensing - Storage → Temp. : -10 ~70℃, Humidity : 0 ~90%RH		
Reaction time(T_{90})		- Reaction Time(T_{90}) : Less then 10sec - Recovering Time(T_{90}) : Less then 30sec		

*T_{90} : 90% of saturation point
*Sensitivity (β) = Rs,gas / Rs,air
- Rs,gas : output resistance after gas inlet, - Rs,air : output resistance in special air

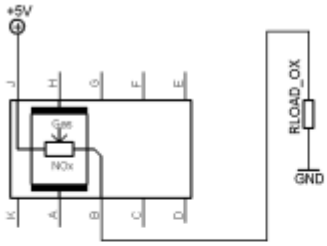
Enllaç de consulta: https://waf-e.dubudisk.com/ogamtech.dubuplus.com/ogamnara@daum.net/O18AmvH/DubuDisk/www/131127_SUM-GSNT11_Ec%EA%B7%9C.pdf

1.2.12 MiCS-2714



MiCS-2714 with recommended supply circuit (top view)

R is 131 Ω. This resistor is necessary to obtain the right temperature on the heater while using a single 5 V power supply. The resulting voltages is typically VH = 1.7 V.



MiCS-2714 with measurement circuit (top view)

The voltage measured on the load resistor is directly linked to the resistance of the sensor. RLOAD must be 820 W at the lowest in order not to damage the sensitive layer.

Parameter	Symbol	Typ	Min	Max	Unit
Heating power	P_H	43	30	50	mW
Heating voltage	V_H	1.7	-	-	V
Heating current	I_H	26	-	-	mA
Heating resistance at nominal power	R_H	66	59	73	Ω

Rating	Symbol	Value / Range	Unit
Maximum heater power dissipation	P_H	50	mW
Maximum sensitive layer power dissipation	Ps	8	mW
Voltage supplyHeating current	Vsupply	4.9 – 5.1	V
Relative humidity range	RH	5 – 95	%RH
Ambient operating temperature	Tamb	-30 – 85	°C
Storage temperature range	Tsto	-40 – 120	°C
Storage humidity range	RHsto	5 - 95	%RH

Enllaç de consulta: https://www.mouser.com/datasheet/2/18/1107_Datasheet-MiCS-2714-1144844.pdf

1.2.13 MQ131

Technical Data

Model No.			MQ131
Sensor Type			Semiconductor
Standard Encapsulation			Bakelite (Black Bakelite)
Detection Gas			Ozone
Concentration			10-1000ppm Ozone
Circuit	Loop Voltage	V_c	≤24V DC
	Heater Voltage	V_H	5.0V±0.2V AC or DC
	Load Resistance	R_L	Adjustable
Character	Heater Resistance	R_H	31Ω±3Ω（Room Tem.）
	Heater consumption	P_H	≤900mW
	Sensing Resistance	R_s	50KΩ-500KΩ(in 50ppm O_3)
	Sensitivity	S	Rs(in air)/Rs(in 50ppm O_3)≥3
	Slope	α	$(R_{50ppm}/R_{10ppm}\ O_3)$
Condition	Tem. Humidity		20℃±2℃；65%±5%RH
	Standard test circuit		Vc:5.0V±0.1V； V_H: 5.0V±0.1V
	Preheat time		Over 48 hours

Power of Sensitivity body(Ps): $Ps=Vc^2\times Rs/(Rs+RL)^2$

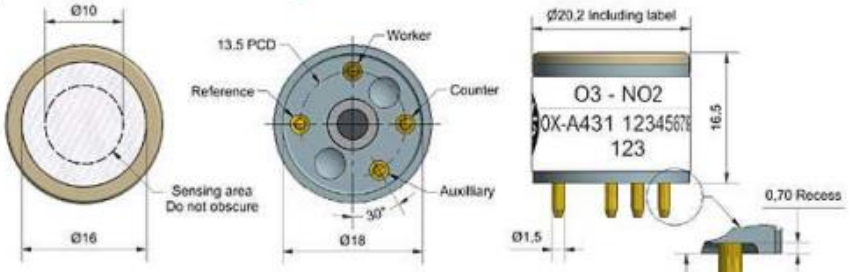
Resistance of sensor(Rs): $Rs=(Vc/VRL-1)\times RL$

Enllaç de consulta:
https://www.digikey.es/htmldatasheets/production/2483660/0/0/1/mq131.pdf

1.2.14 OX-A431

Technical Specification

Figure 1 OX-A431 Schematic Diagram Patented



All dimensions in millimetres (± 0.15mm)

Top View Bottom View Side View

Specification O_3 Sensing

PERFORMANCE						
	Sensitivity	nA/ppm at 1ppm O_3				-200 to -650
	Response time	t_{90} (s) from zero to 1ppm O_3				< 80
	Zero current	nA in zero air at 20°C				-70 to +70
	Noise*	±2 standard deviations (ppb equivalent)				15
	Range	ppm O_3 limit of performance warranty				20
	Linearity	ppm error at full scale, linear at zero and 20ppm O_3				< ±0.5
	Overgas limit	maximum ppm for stable response to gas pulse				50
	*** Tested with Alphasense AFE low noise circuit**					
LIFETIME	Zero drift	ppb equivalent change/year in lab air				0 to 20
	Sensitivity drift	% change/year in lab air, monthly test				< -20 to -40
	Operating life	months until 50% original signal (24 month warranted)				> 24
ENVIRONMENTAL						
	Sensitivity @ -20°C	(% output @ -20°C/output @ 20°C) @ 2ppm O_3				60 to 80
	Sensitivity @ 40°C	(% output @ 40°C/output @ 20°C) @ 2ppm O_3				80 to 105
	Zero @ -20°C	nA				0 to 25
	Zero @ 40°C	nA				20 to 90
CROSS SENSITIVITY	H_2S	sensitivity % measured gas	@	5ppm	H_2S	< -80
	NO	sensitivity % measured gas	@	5ppm	NO	< 5
	Cl_2	sensitivity % measured gas	@	5ppm	Cl_2	< 100
	SO_2	sensitivity % measured gas	@	5ppm	SO_2	< -3
	CO	sensitivity % measured gas	@	5ppm	CO	< -3
	C_2H_4	sensitivity % measured gas	@	100ppm	C_2H_4	< 0.1
	NH_3	sensitivity % measured gas	@	20ppm	NH_3	< 0.1
	H_2	sensitivity % measured gas	@	100ppm	H_2	< 0.1
	CO_2	sensitivity % measured gas	@	5% Vol	CO_2	< 0.1
	Halothane	sensitivity % measured gas	@	100ppm	Halothane	< 0.1
KEY SPECIFICATIONS						
	Temperature range	°C				-30 to 40
	Pressure range	kPa				80 to 120
	Humidity range	% rh continuous				15 to 85
	Storage period	months @ 3 to 20°C (stored in sealed pot)				6
	Load resistor	Ω (AFE circuit recommended)				33 to 100
	Weight	g				< 6

Enllaç de consulta: https://www.alphasense.com/wp-content/uploads/2019/09/OX-A431.pdf

1.2.15 MiCs-2614

ELECTRICAL CHARACTERISTICS

Rating	Symbol	Value/Range	Unit
Maximum heater power dissipation (see note 1)	P_H	95	mW
Maximum sensitive layer power dissipation	P_S	1	mW
Voltage supply	V_{supply}	4.9 – 5.1	V
Relative humidity range	R_H	5 – 95	%RH
Ambient operating temperature	T_{amb}	-40 – 70	°C
Storage temperature range (see note 2)	T_{sto}	-40 – 50	°C
Storage humidity range	RH_{sto}	5 - 95	%RH

OPERATING CONDITIONS

Parameter	Symbol	Typ	Min	Max	Unit
Heating power (see note 3)	P_H	80	66	95	mW
Heating voltage	V_H	2.35	-	-	V
Heating current	I_H	34	-	-	mA
Heating resistance at nominal power (see note 4)	R_H	68	58	78	Ω

SENSITIVITY CHARACTERISTICS

Characteristic	Symbol	Typ	Min	Max	Unit
O_3 detection range	FS		10	1000	ppm
Sensing resistance in air	R_0	11	3	60	kΩ
Sensitivity factor (see note 5)	S_R	2	1.5	4	-

Enllaç de consulta: https://datasheet.octopart.com/MICS-2614-E2V-datasheet-8615830.pdf

1.2.16 MQ7

TECHNICAL DATA MQ-7 GAS SENSOR

FEATURES

* High sensitivity to carbon monoxide
* Stable and long life

APPLICATION

They are used in gas detecting equipment for carbon monoxide(CO) in family and industry or car.

SPECIFICATIONS

A. Standard work condition

Symbol	Parameter name	Technical condition	Remark
Vc	circuit voltage	5V±0.1	Ac or Dc
V_H (H)	Heating voltage (high)	5V±0.1	Ac or Dc
V_H (L)	Heating voltage (low)	1.4V±0.1	Ac or Dc
R_L	Load resistance	Can adjust	
R_H	Heating resistance	33Ω ±5%	Room temperature
$T_{H(H)}$	Heating time (high)	60±1 seconds	
$T_{H(L)}$	Heating time (low)	90±1 seconds	
PH	Heating consumption	About 350mW	

b. Environment conditions

Symbol	Parameters	Technical conditions	Remark
Tao	Using temperature	-20℃-50℃	
Tas	Storage temperature	-20℃-50℃	Advice using scope
RH	Relative humidity	Less than 95%RH	
O_2	Oxygen concentration	21%(stand condition) the oxygen concentration can affect the sensitivity characteristic	Minimum value is over 2%

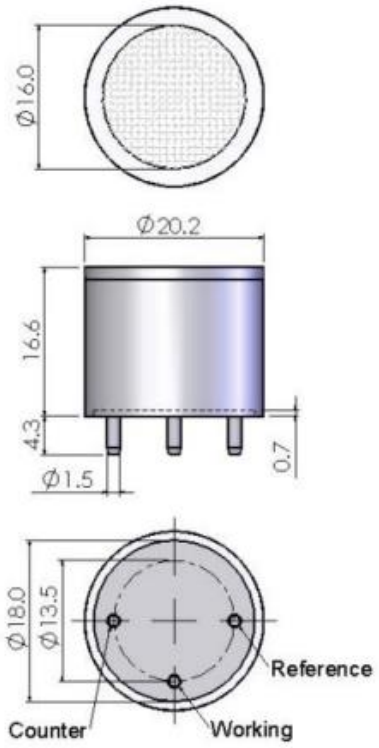
c. Sensitivity characteristic

symbol	Parameters	Technical parameters	Remark
Rs	Surface resistance Of sensitive body	2-20k	In 100ppm Carbon Monoxide
a (300/100ppm)	Concentration slope rate	Less than 0.5	Rs (300ppm)/Rs(100ppm)
Standard working condition	Temperature -20℃±2℃ relative humidity 65%±5% RL:10KΩ ±5%		
	Vc:5V±0.1V VH:5V±0.1V VH:1.4V±0.1V		
Preheat time	No less than 48 hours	Detecting range: 20ppm-2000ppm carbon monoxide	

Enllaç de consulta: https://www.mouser.com/datasheet/2/321/605-00007-MQ-7-Datasheet-370460.pdf

1.2.17 4-CO-500

Outline Dimensions



All dimensions are in millimetres mm.

SPECIFICATION – 4 SERIES

Operating Principle:	Electrochemical, 3-electrode cell
Gas Detected:	Carbon Monoxide CO
Measurement Range:	0 – 500 ppm
Maximum Overload:	2000 ppm
Resolution:	1 ppm
Expected Operating Life:	2 years in air
Temperature Range:	-20°C to +50°C
Humidity Range (non-condensing):	15 – 90% RH
Response Time (T90):	≤ 30 seconds
Long Term Sensitivity Drift:	< 2% signal per month
Linearity at Standard Range:	Linear
Sensitivity:	0.070 +/- 0.015 µA/ppm
Baseline (20°C):	< ± 0.2 µA
Baseline Drift (-20°C to 40°C):	0 to 3 ppm equivalent
Pressure range:	90 to 110 kPa
Bias Potential:	0 mV
Warranty Period:	18 months from date of despatch
Storage Life:	6 months in original sealed container
Storage Temperature:	0°C to +20°C
Weight (approx):	5 g
Orientation Sensitivity:	None
Part Number:	2112B0052400

Enllaç de consulta: https://euro-gasman.com/media/wysiwyg/Gas_Sensors/SOLIDSENSE/4_CO_500.pdf

1.2.18 3SP-CO-1000

SPECIFICATIONS

Measurement Range	0 to 1,000 ppm
Detection Limit	0.5 ppm
Resolution	< 100 ppb (instrumentation dependent)
Repeatability	< ± 2 % of reading
Response Time – T(90)	< 30 seconds (15 seconds typical)
Sensitivity	4.75 ± 2.75 nA/ppm
Overload	Passes EN50291-1 Sec. 5.3.6 5,000 ppm overload
Expected Operating Life	> 5 years (10 years @ 23 ± 3 °C; 40 ± 10% RH)
Operating Temperature Range	-30 to 55 °C (-20 to 40 °C continuous recommended)
Operating Humidity Range – non-condensing	15 to 95% recommended continuous 0 to >95% RH - intermittent
Operating Bias	0 to 5 mV
Power Consumption	10 to 50 uW (circuit & ambient CO dependent)

Enllaç de consulta: https://www.spec-sensors.com/wp-content/uploads/2016/04/3SP_CO_1000-C-Package-110-109.pdf

1.2.19 HPMA1155C0

Particulate Matter Sensors
HPM Series

Table 1. Specifications

Characteristic	Standard HPMA115S0-XXX 	Compact HPMA115C0-003  HPMA115C0-004 
Operating principle	laser scattering	
Detection[1,2]	PM2.5, PM10	PM1.0, PM2.5, PM4.0, PM10
Output data[1,2]	PM2.5 in µg/m³, PM10 in µg/m³	PM1.0 in µg/m³, PM2.5 in µg/m³, PM4.0 in µg/m³, PM10 in µg/m³
Concentration range	0 µg/m³ to 1,000 µg/m³	
Accuracy (at 25°C ±5°C): **0 µg/m³ to 100 µg/m³** **100 µg/m³ to 1000 µg/m³**	**PM2.5:** ±15 µg/m³ **PM2.5:** ±15 %	**PM2.5:** ±15 µg/m³; **PM1.0, PM4.0, PM10:** ±25 µg/m³ **PM2.5:** ±15 %; **PM1.0, PM4.0, PM10:** ±25%;
Response time	<6 s	
Supply voltage[3]	5 V ±0.2 V	
Switching frequency max.	100 kHz	
Ripple amplitude max.	20 mV	
R.M.S noise max.	1 mV (noise bandwidth 10 MHz)	
Standby current (at 25°C ±5°C)	<20 mA	
Supply current (at 25°C ±5°C)	<80 mA	
Inrush current max. (at 25°C ±5°C)	600 mA	
Temperature: **operating** **storage**	-20°C to 50°C [-4°F to 122°F] -30°C to 65°C [-22°F to 149°F]	-20°C to 70°C [-4°F to 158°F] -40°C to 85°C [-40°F to 185°F]
Humidity (operating and storage)	0 %RH to 95 %RH non-condensing	
Output protocol[4]	UART; baud rate: 9600, databits: 8, stopbits: 1, parity: no	
Operating time: **continuous mode** **intermittent mode**	10 years depends on duty cycle	
Laser class	Laser Class 1: IEC/EN 60825-1: 650 nm	
ESD	±4 kV contact, ±8 kV air per IEC 61000-4-2	
Radiated immunity	1 V/m (80 MHz to 1000 MHz) per IEC 61000-4-3	
Fast transient burst	±0.5 kV per IEC61000-4-4	
Immunity to conducted disturbances radiated emissions	3 V per IEC61000-4-6	
Radiated emissions	40 dB 30 MHz to 230 MHz; 47 dB 230 MHz to 1000 MHz per CISPR 14	
Conducted emissions	0.15 MHz to 30 MHz in compliance with CISPR 14	
Dimensions (L X W X H)	43 mm x 36,00 mm x 23,7 mm [1.69 in x 1.42 in x 0.93 in]	44 mm x 36 mm x 12 mm [1.73 in x 1.42 in x 0.48 in]

[1] PM2.5 is particulate matter ≤2.5 µm in diameter; PM10 is particulate matter ≤10 µm in diameter.
[2] PM1.0 in µg/m³, PM4.0 in µg/m³, and PM10 in µg/m³ are calculated from PM 2.5 readings.
[3] Power supply output should contain one de-coupling capacitor (22 µF), and two ceramic capacitors (100 nF, 10 nF), if ripple amplitude max. or R.M.S. noise max. exceeds specifications.
[4] Contact Honeywell for other output options.

CLASS 1
LASER PRODUCT

Enllaç de consulta: https://prod-edam.honeywell.com/content/dam/honeywell-edam/sps/siot/en-us/products/sensors/particulate-matter-sensors-hpm-series/documents/sps-siot-particulate-hpm-series-datasheet-32322550-ciid-165855.pdf

1.2.20 PMSA003

Technical Index

Parameter	Index	unit
Range of measurement	0.3~1.0；1.0~2.5；2.5~10	Micrometer（μ m）
Counting Efficiency	50%@0.3μ m 98%@>=0.5μ m	
Effective Range（PM2.5 standard）	0~500	μ g/m³
Maximum Range（PM2.5 standard）*	⩾1000	μ g/m³
Resolution	1	μ g/m³
Maximum Consistency Error (PM2.5 standard data)*	±10%@100~500μ g/m³ ±10μ g/m³ @0~100μ g/m³	
Standard Volume	0.1	Litre（L）
Single Response Time	＜1	Second（s）
Total Response Time	⩽10	Second（s）
DC Power Supply	Typ:5.0 Min:4.5 Max: 5.5	Volt（V）
Active Current	⩽100	Milliampere（mA）
Standby Current	⩽200	Microampere（μ A）
Interface Level	L <0.8 @3.3 H >2.7@3.3	Volt（V）
Working Temperature Range	-10~+60	℃
Working Humidity Range	0~99%	
Storage Temperature Range	-40~+80	℃
MTTF	⩾3	Year（Y）
Physical Size	38×35×12	Millimeter（mm）

Note 1: Maximum range means that the highest output value of the PM2.5 standard data is not less than 1000.
Note 2:"PM2.5 standard data" is the "data2" in the appendix.

Enllaç de consulta: https://m.eleparts.co.kr/data/goods_old/data/PMSA003.pdf

1.2.21 SDS011

Technical Parameters

No	Item	Parameter	Note
1	Measurement parameters	PM2.5,PM10	
2	Range	0.0-999.9 μg /m^3	
3	Rated voltage	5V	
4	Rated current	70mA±10mA	
5	Sleep current	<4 mA	Lase&Fan sleep
6	Temperature range	Storage environment：-20～+60℃	
		Work environment：-10～+50℃	
7	Humidity range	Storage environment：Max 90%	
		Work environment：Max 70%	
8	Air pressure	86KPa~110KPa	
9	Corresponding time	1s	
10	Serial data output frequency	1Hz	
11	Minimum resolution of particle	0.3 μm	
12	Counting yield	70%@0.3μm 98%@0.5μm	
13	Relative error	Maximum of ±15% and ±10μg/m^3	25℃, 50%RH
14	Product size	71x70x23mm	
15	Certification	CE/FCC/RoHS	

Power requirement

Power Voltage：4.7~5.3V

Power supply：>1W

Supply voltage ripple：<20mV

Enllaç de consulta: https://cdn-reichelt.de/documents/datenblatt/X200/SDS011-DATASHEET.pdf