





# SprintIR<sup>®</sup>-6S

## High Speed CO<sub>2</sub> Sensor

### DESCRIPTION

The SprintIR<sup>®</sup>-6S is a small footprint high flow through NDIR CO<sub>2</sub> sensor using state-of-the-art solid-state LED optical technology. The low power LEDs are manufactured in-house, giving GSS complete control of the CO<sub>2</sub> sensor signal chain.

The SprintIR<sup>®</sup>-6S is designed for applications that need fast response time and high-speed measurement capability. The SprintIR<sup>®</sup>-6S takes 20 readings per second, making it ideal for equipment that needs real-time CO<sub>2</sub> gas analysis or monitoring.

The sensor is available in multiple versions, capable of measuring CO<sub>2</sub> levels up to 100% concentration.

### FEATURES

- 20 readings per second
- High flow throughput capability
- Standard flow adaptor or custom options
- 70ppm typical measurement accuracy
- Measurement range up to 100%
- Solid state NDIR LED optical technology
- UART control and data interface
- Built-in auto-zeroing

#### **APPLICATIONS**

- Healthcare
- Food Packaging
- Sport Science
- CO<sub>2</sub> Fire Suppression Deployment

#### **BLOCK DIAGRAM**





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#### **ORDERING INFORMATION**

#### SPRINTIR-6S-X-X

Х	Measurement Range
5	0-5%
10	0-10%
20	0-20%
60	0-60%
100	0-100%

 Х	Gas Cover
Blank	Flow through adaptor as
	standard
М	Membrane instead of
	flow adaptor

#### Notes:

- 1. Sensors are shipped individually
- 2. Custom flow through adaptors are available, contact GSS for options

### See separate data sheet for SprintIR®-6S evaluation kit options.



### PACKAGE DRAWING: SprintIR®-6S







Weight = ~10g

### **PIN-OUT DESCRIPTION: SprintIR®-6S**

PIN	NAME	TYPE DESCRIPTION			
1	Rx_In	Digital Input	UART Receive Input		
2	Tx_Out	Digital Output	UART Transmit Output		
3	GND	Supply	Sensor ground		
4	VDD	Supply	Sensor supply voltage		



## PACKAGE DRAWING: SprintIR®-6S-M (WITH MEMBRANE COVER)







Weight = ~10g

#### **PIN-OUT DESCRIPTION: SprintIR®-6S-M**

PIN	NAME	TYPE DESCRIPTION			
1	Rx_In	Digital Input	UART Receive Input		
2	Tx_Out	Digital Output	UART Transmit Output		
3	GND	Supply	Sensor ground		
4	VDD	Supply	Sensor supply voltage		

#### Gas Sensing Solutions Ltd.

#### Production Data, Revision 4.12, 8 December 2021



#### **ABSOLUTE MAXIMUM RATINGS**

Absolute Maximum Ratings are stress ratings only. Permanent damage to the SprintIR<sup>®</sup>-6S may be caused by continuously operating at or beyond these limits. The SprintIR<sup>®</sup>-6S functional operating limits and guaranteed performance specifications are given at the test conditions specified.



ESD Sensitive Device. This sensor uses ESD sensitive components. It is therefore generically susceptible to damage from excessive static voltages. Proper ESD precautions must be taken during handling and storage of this device.

CONDITION	MIN	MAX
Supply Voltages	-0.3V	+6.0V
Voltage Range Digital Inputs	GND -0.3V	5V
Operating Temperature Range (T <sub>a</sub> )		
- Standard	0°C	+50°C
Storage Temperature Range	-40°C	+70°C
Humidity Range (RH), Non-	0	95%
Condensing		
Operating Ambient Pressure Range	500mbar	2bar

#### **RECOMMENDED OPERATING CONDITIONS**

PARAMETER	SYMBOL	MIN	ТҮР	MAX	UNIT
Supply	VDD	3.25	3.3	5.5	V
Ground	GND		0		V

#### MECHANICAL SEALING – For Sensor with Flow Port Adaptor Only

CONDITION	MIN	MAX
Test gauge Pressure <sup>1</sup>	0.3bar	
Burst gauge Pressure <sup>2</sup>	2bar	

#### Test Conditions Unless Otherwise Specified

1. The mechanical sealing between the flow adaptor and sensor housing is tested by pressurising the gas chamber to 0.3bar. The pressure reading must not drop by more than 1mbar within 30 seconds

- 2. Guaranteed by design, not tested
- 3. Sensors with a membrane cover do not have an air-tight seal between the sensor casing and the main sensor body.



### **CO2 PERFORMANCE CHARACTERISTICS**

#### **Test Conditions Unless Otherwise Specified**

VDD = 3.3V, GND = 0V, RH = 0% non-condensing, T= 25°C, Pressure = 1013mbar, Flow Rate = 0.1l/minute

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	ТҮР	ΜΑΧ	UNIT
CO <sub>2</sub> measurement			0		5	%
range			0		20	%
C		-	0		60	%
			0		100	%
Accuracy (0-5% sensor)		@25°C, @ 2% CO2				
Accuracy (0-10% sensor)		@25°C, @ 9% CO2			±(70	
Accuracy (0-20% sensor)		@25°C, @ 12% CO2			+5%rdg)	ppm
Accuracy (0-60% sensor)		@25°C, @ 20% CO2				
Accuracy (0-100% sensor)		@25°C, @ 60% CO <sub>2</sub>			±(300 +5%rdg)	ppm
Accuracy		@25°C		±(70 +5%rdg)		ppm
(Peak-Peak) 0-60%		0°C to +50°C, after zero @25°C		±(70 +5%rdg +~0.1% per °C)		ppm
Accuracy (Peak-Peak) 0-100%		@25°C		±(300 +5%rdg)		ppm
		0°C to +50°C, after zero @25°C		±(300 +5%rdg +~0.1% per °C)		ppm
CO <sub>2</sub> RMS Noise		Digital filter setting 16		6		ppm
Time to Valid Measurement After Power-On		First value from sensor		0.3		secs
Response Time		T <sub>90</sub> , no filter @ 0.1l/min		3.6		secs
		T <sub>90</sub> , filter = 16 @ 0.1l/min		4.2		
Repeatability		@25°C, 0-60%		±(70 +5%rd)		ppm
· ·		@25°C, 0-100%		±(300 +5%rdg)		ppm
Current		Peak current when sampling		35		mA
Consumption		Peak at turn-on		40		mA
		SLEEP Mode (K 0 command)		0.01		mA



### ELECTRICAL CHARACTERISTICS

PARAMETER	SYMBOL	TEST	MIN	ТҮР	MAX	UNIT
		CONDITIONS				
Digital Input/Output						
Input HIGH Level			1.8			V
Input LOW Level					1.0	V
Output HIGH Level		I <sub>он</sub> = +1mA	2.6		3.0	V
Output LOW Level		I <sub>OL</sub> = -1mA			0.4	V

#### **POWER CONSUMPTION - SprintIR®-6S**

#### Test Conditions Unless Otherwise Specified

VDD = 3.3V, GND = 0V, RH = 0% non-condensing, T= 25°C, Pressure = 1013mbar, Flow Rate = 0.2l/minute

SETTING	SYMBOL	TEST CONDITIONS	VDD		Total
					Power
			V	I (mA)	mW
Active, K0 SLEEP			3.3	0.01	0.03
mode, no					
measurement					
Active, K1 mode		Default settings	3.3	9	30
whilst taking					
measurements					



#### **RESPONSE TIME, FLOW RATE AND MEASUREMENT RATE - SprintIR®-6S**

The SprintIR<sup>®</sup>-6S response time is dependent on several interrelated factors.

#### **Measurement Rate**

The measurement rate is fixed at 20 readings per second.

#### Gas Exchange Rate

The most important factor is the gas exchange rate. This is the amount of time it takes for the gas to enter the CO<sub>2</sub> measurement chamber, measured and then replaced. The sensor has a gas measurement chamber volume of approximately 2.8ml. As a general rule of thumb, to properly exchange the gas in the chamber, there needs to be a x5 volume of gas passed through the sensor. Therefore, approximately 14ml of gas needs to flow through the sensor for each reading.

$$Max Flow Rate (l/min) = \frac{20 \ reading/s * 60s * 14ml}{1000}$$

#### **Digital Filter Setting**

The sensor outputs both filtered and raw unfiltered  $CO_2$  readings. If the filtered measurement data is used, the response time will also depend on the filter setting or the algorithm to process the raw data.

The table below shows how the response time varies with filter setting and flow rate.

Gas delivery	Measurement			easurement T <sub>50</sub> Response time 0.1l/min (s) T <sub>50</sub> Response time 1l/m		ne 1l/min (s)
	frequency (Hz)			No filter	Filter 16	
Flow Adaptor	20	0.6s	1.4s	0.1s	1.2s	

Gas delivery	Measurement	T <sub>90</sub> Response time 0.1l/min (s)		n (s)   T <sub>90</sub> Response time 1l/min (s	
	frequency (Hz)	No filter	Filter 16	No filter	Filter 16
Flow Adaptor	20	3.6s	4.2s	0.2s	2.4s



#### METHOD OF OPERATION

After power is applied to the SprintIR<sup>®</sup>-6S, the sensor will automatically start to take  $CO_2$  measurements using the Mode 1 default settings, where the sensor is pre-programmed to send  $CO_2$  measurement data at 20 readings per second.

The measurement rate is fixed at 20 readings per second at a fixed 9600 baud rate. The sensor will return the previous CO<sub>2</sub> measurement results if the user requests more frequent measurements.

The SprintIR<sup>®</sup>-6S has 3 potential modes of operation.

#### MODE 0 COMMAND MODE

In this mode, the sensor is in a SLEEP mode, waiting for commands. No measurements are made. There is no latency in command responses. All commands that report measurements or alter the zero-point settings are disabled in Mode 0. Mode 0 is NOT retained after power cycling.

#### **MODE 1 STREAMING MODE**

This is the factory default setting. Measurements are reported 20 per second. Commands are processed when received, except during measurement activity, so there may be a time delay of up to 10ms in responding to commands.

#### **MODE 2 POLLING MODE**

In polling mode, the sensor only reports readings when requested. The sensor will continue to take measurements in the background, but the output stream is suppressed until data is requested. The sensor will always power up in streaming or polling mode, whichever mode was used before the power cycle.



#### **DIGITAL FILTER**

The CO<sub>2</sub> gas chamber is illuminated with a nominal 4.25um wavelength LED and the signal received using a photo-diode. The signal from the photo-diode is processed and filtered by the sensor to remove noise and provide an accurate CO<sub>2</sub> reading. High frequency noise coming from the sampling process is removed using a proprietary lowpass filter. The digital filter setting can be varied, allowing the user to reduce measurement noise at the expense of the measurement response time. The ideal digital filter setting is application specific and is normally a balance between CO<sub>2</sub> reading accuracy and response time. The SprintlR<sup>®</sup>-6S sensor will also output the raw unfiltered CO<sub>2</sub> measurement data. This data can be post processed using alternative filter algorithms.



The graph above shows the effects of the filter on the  $CO_2$  measurement data (Z or z). The unfiltered output is shown in orange and the filtered output shown in blue.



The graph above shows the effect of the filter on response times. Increasing the filter setting increases the measurement output response time.  $T_{90}$  is the time to 90% of reading. The SprintIR<sup>®</sup>-6S takes 20 readings per second. The flow rate was set at 0.2l/min.



Sampling noise is progressively reduced with higher digital filter settings. It is recommended the user sets the highest value digital filter setting without compromising the required flow rate.

Flow Rate	Recommended Digital Filter Setting 'a'
0.1litre/minute	64
0.5litre/minute	32
1litre/minute	16
5litre/minute	8



#### ZERO POINT SETTING

There are a several methods available to the user to set the zero point of the sensor. The recommended user method is to zero in a known gas concentration. In all cases, the best zero is obtained when the gas concentration is stable, and the sensor is at a stabilised temperature.

Note that zero-point setting is not cumulative and only the latest zero-point setting is effective. For example, there is no benefit in setting in nitrogen, and then setting in a known concentration gas. The sensor will store only the latest zero point.

To improve zeroing accuracy, the recommended digital filter setting is 32. See the 'A' command.

#### ZERO IN A KNOWN GAS CONCENTRATION

Place the sensor in a known gas concentration, power up the sensor and allow time for the sensor temperature to stabilise, and for the gas to be fully diffused into the sensor.

Send the **ZERO IN A KNOWN GAS CONCENTRATION** command X to the sensor. The sensor will be zeroed using the known gas concentration level sent by the user. The concentration value written to the sensor must be scaled dependent on the sensor  $CO_2$  measurement range. The multiplier for the scaling factor is set according to the range of the sensor, see the '.' command.

#### **ZERO IN NITROGEN**

Place the sensor in nitrogen gas and allow time for the sensor temperature to stabilise and the gas to be fully diffused into the sensor. Send the **ZERO IN NITROGEN** command U to the sensor. The sensor is zeroed assuming a  $0ppm CO_2$  environment.

#### **ZERO IN FRESH AIR**

If there is no known concentration gas or nitrogen available, the sensor zero point can be set in fresh air. Ambient  $CO_2$  concentrations in fresh air are typically 400ppm. The  $CO_2$  concentration fresh air level is programmable over a range from 0ppm to the full scale of the sensor.

Place the sensor in a fresh air environment and allow time for the sensor temperature to stabilise, and for the fresh air to be fully diffused into the sensor. Power up the sensor, write the G command to the sensor. The concentration value written to the sensor must be scaled dependent on the sensor CO<sub>2</sub> measurement range. The sensor can use the default fresh air CO<sub>2</sub> concentration value (400ppm), or the user can write a different fresh air value to the sensor if desired.



#### **ZERO POINT ADJUSTMENT**

If the CO<sub>2</sub> concentration and the sensor reported concentration are known, the zero point can be adjusted using the known concentration to fine tune the zero point. For example, if the sensor has been in an environment that has been exposed to outside air, and the sensor reading is known at that time, the zero point can be fine-tuned to correct the reading. This is typically used to implement automated auto-zero routines.

The known  $CO_2$  concentration value and the reported  $CO_2$  value from the sensor can be sent to the sensor using the **ZERO POINT ADJUSTMENT** command F.

#### **AUTO-ZERO FUNCTION**

The sensor has a built-in auto-zero function. In order to function correctly, the sensor must be exposed to typical background levels (400-450ppm) at least once during the auto-zeroing period. For example, many buildings will drop quickly to background CO<sub>2</sub> levels when unoccupied overnight or at weekends. The auto-zeroing function uses the information gathered during these periods to re-zero. The sensor will reset the 'zero' level every time it does an auto-zero. Auto-zero is disabled by default. If the sensor is powered down, the auto-zero is reset to default values.

The auto-zero function works in the same way as the **ZERO IN FRESH AIR** command. The auto-zero function is disabled by default, but can be enabled to operate automatically, or zeroing can be forced. The user can also independently adjust the CO<sub>2</sub> level used for auto-zero Typically, it is set to the same value as the **ZERO IN FRESH AIR** value, but it can also be set at a different level if desired.

### **AUTO-ZERO INTERVALS**

The auto-zero period can be programmed by the user. The sensor can be programmed to undertake an initial auto-zero after power-on. Thereafter, the auto-zero period can be set independently of the start-up auto-zero time. Note, the auto-zero settings are reset if the sensor is powered down.

#### **AUTO-ZERO SETTINGS**

By default, the sensor will automatically 'zero' using the measured  $CO_2$  level sampled during the auto-zeroing period. The user can alter the behaviour of the sensor as a result of the auto-zeroing process.



### PRESSURE AND CONCENTRATION LEVEL COMPENSATION

NDIR gas sensors detect the concentration of gas by measuring the degree of light absorption by the gas analyte. The degree of light absorption is converted into a concentration reported by the sensor.

The absorption process is pressure and gas concentration dependent. In general, as the pressure increases, the reported gas concentration also increases. As the pressure decreases, the reported concentration decreases. This effect takes place at a molecular level and is common to all NDIR gas sensors.

GSS sensors are calibrated at 1013mbar and 450ppm  $CO_2$ . The reading will vary due to pressure and  $CO_2$  concentration. It is possible to correct for the effects of pressure and concentration by setting a compensation value. This will apply a permanent correction to the output of the sensor, depending on the compensation value. The compensation value needs to be written to the sensor and will overwrite the default 1013mbar and 450ppm  $CO_2$  value. The new compensation value will be used for all subsequent measurements and will be retained after a power cycle.

Altitude	Altitude	Pressure	Sea Level	%	CO <sub>2</sub>	Compensation
(ft.)	(m)	(mbar)	Difference	Change	Measurement	Value
				per	Change (%)	
0	0	1,013	0	0.14	0	8,192
500	153	995	18	0.14	3	8,398
1,000	305	977	36	0.14	5	8,605
1,500	458	960	53	0.14	7	8,800
2,000	610	942	71	0.14	10	9,006
2,500	763	925	88	0.14	12	9,201
3,000	915	908	105	0.14	15	9,396
3,500	1,068	891	122	0.14	17	9,591
4,000	1,220	875	138	0.14	19	9,775
4,500	1,373	859	154	0.14	22	9,958
5,000	1,525	843	170	0.14	24	10,142
6,000	1,830	812	201	0.14	28	10,497
7,000	2,135	782	231	0.14	32	10,841
8,000	2,440	753	260	0.14	36	11,174
9,000	2,745	724	289	0.14	40	11,506
10,000	3,050	697	316	0.14	44	11,816

#### ALTITUDE COMPENSATION TABLE

Other compensation values can be calculated using the following formula.

$$Compensation Value = 8192 + \left(\frac{Sea \ Level \ Difference * 0.14}{100}\right) * 8192$$



The pressure compensation values calculated above are only approximate and only valid for concentrations below 1%. For higher accuracy compensation, the sensor output must be adjusted for both pressure and concentration as the  $CO_2$  level measured by the sensor is affected by both ambient pressure and gas concentration levels. To calculate the adjusted  $CO_2$  level, use the following calculation.

Corrected CO2 Value =  $\frac{CO2 Measurement Value from Sensor (C1)}{1 + Y(1013 - P)}$ 

where,

C1 = Concentration reading from sensor

P = Pressure in mbar

Where concentration is < 1500ppm.

 $Y = 2.6661 \times 10^{-16} x \, C1^4 - 1.1146 \times 10^{-12} x \, C1^3 + 1.7397 \times 10^{-9} x \, C1^2 - 1.2556 \times 10^{-6} x \, C1 - 9.8754 \times 10^{-4}$ 

Where concentration is >1500ppm.

 $Y = 2.811 \times 10^{-38} x \, C1^6 - 9.817 \times 10^{-32} x \, C1^5 + 1.304 \times 10^{-25} x \, C1^4 - 8.126 \times 10^{-20} x \, C1^3 + 2.311 \times 10^{-14} x \, C1^2 - 2.195 \times 10^{-9} x \, C1 - 1.471 \times 10^{-3}$ 



#### **CONTROL INTERFACE**

The SprintIR<sup>®</sup> family of sensors are controlled by writing and reading from the sensor via its UART interface. The Rx\_In and Tx\_Out pins are normally high, suitable for direct connection to a UART. If the sensor is to be read by a true RS232 device (e.g. a PC), it is necessary to pass through a level converter to step up/down the voltage and invert the signal.

#### **CONTROL INTERFACE TIMING - UART MODE**

PARAMETER	SYMBOL	MIN	ТҮР	MAX	UNIT
Baud Rate			9600		Bits/s
Data Bits		8			
Parity		None			
Stop Bits		1			
Hardware Flow Control	e Flow Control None				

#### UART COMMAND PROTOCOL

All UART commands must be terminated with a carriage return and line feed <CR><LF>, hex 0x0D 0x0A. In this document, this is shown as '\r\n'. UART commands that take a parameter always have a space between the letter and the parameter. The sensor will respond with a '?' if a command is not recognised. The two most common causes are missing spaces or missing <CR><LF> terminators.

All command communications are in ASCII and are terminated by carriage return, line feed (0x0D 0x0A). This document uses the protocol "\r\n" to indicate the carriage return line feed. All responses from the sensor, including measurements, have a leading space (ASCII character 32).

The character '#' represents an ASCII representation of a numeric character (0-9). Note there is a space between the first letter and any parameter. For example, the X command reads "X space 2000 carriage return line feed".

#### **UART OPERATION**

When initially powered, the sensor will immediately start to transmit a CO<sub>2</sub> reading on receiving any character.

The CO<sub>2</sub> measurement is reported as:

 $Z ##### \land r \land n$ 

where Z ##### shows the CO<sub>2</sub> concentration.

Note that all outputs from the sensor have a leading space.



### UART INTERFACE SUMMARY

Syntax	Use	Example	Response	Comments
A ###\r\n	Set value of the	A 128\r\n	A 00128\r\n	See "Digital Filter"
	digital filter			
a\r\n	Return the value of	a\r\n	a 00128\r\n	See "Digital Filter"
	the digital filter			
F ##### #####\r\n	Fine Tune the zero	F 410 400\r\n	F 33000\r\n	See <b>"Zero Point</b>
	point			Settings"
G\r\n	Zero-point setting	G\r\n	G 33000\r\n	See <b>"Zero Point</b>
	using fresh air			Settings"
K #\r\n	Switches the sensor	K 1\r\n	K 00001\r\n	
	between different			
	modes			
M #####\r\n	Sets the number of	M 6\r\n	M 00006\r\n	See "Measurement
	measurement data			Data Output"
	types output by the			
	sensor			
P 8 ###\r\n	Sets value of CO <sub>2</sub>	P 8 1\r\n	P 00008 00001\r\n	Two-byte value,
P 9 #\r\n	background	P 9 144\r\n	P 00009 00144\r\n	P 8 = MSB
	concentration in ppm			P 9 = LSB
	for auto-zeroing			
				400ppm in the
				example
P 10 ###\r\n	Sets value of CO <sub>2</sub>	P 10 1\r\n	P 00010 00001\r\n	Two-byte value,
P 11 #\r\n	background	P 11 144\r\n	P 00011 00144\r\n	P 10 = MSB
	concentration in ppm			P 11 = LSB
	used for zero-point			
	setting in fresh air			400ppm in the
				example
Q\r\n	Reports the latest	Q\r\n	H 12345 T 12345 Z	
	measurement data		00010\r\n	
	types, as defined by			
	'M'			
S #####\r\n	Sets the pressure and	S 8192\r\n	S 08192\r\n	See "Pressure and
	concentration			Concentration
	compensation value			Compensation"
s\r\n	Returns the pressure	s\r\n	s 08192\r\n	See "Pressure and
	and concentration			Concentration
	compensation value			Compensation"
U\r\n	Zero-point setting	U\r\n	U 33000\r\n	See "Zero Point
	using nitrogen			Setting"
u #####\r\n	Manual setting of the	u 32997\r\n	u 32997\r\n	See "Zero Point
	zero point			Setting"
X #####\r\n	Zero-point setting	X 2000\r\n	X 32997\r\n	See "Zero Point
	using a known gas			Setting"
	concentration			
Y\r\n	Return firmware	Y\r\n	Returns <u>two</u> lines	
	version and sensor			
	serial number			
Z\r\n	Return the most	Z\r∖n	Z 01521\r\n	
	recent filtered CO <sub>2</sub>			
	measurement in ppm			

#### Gas Sensing Solutions Ltd.

#### Production Data, Revision 4.12, 8 December 2021



High Speed C	O <sub>2</sub> Sensor
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Syntax	Use	Example	Response	Comments
z\r\n	Return the most	z\r\n	Z 01521\r\n	
	recent unfiltered CO <sub>2</sub>			
	measurement in ppm			
@ #.# #.#\r\n	Sets the timing for	@ 1.0 8.0\r\n	@ 1.0 8.0\r\n	See <b>"Auto-Zero</b>
	initial and interval			Function" for details
	auto-zero periods			
@\r\n	Returns the Auto-	@ 1.0 8.0\r\n	@ 1.0 8.0\r\n	See <b>"Auto-Zero</b>
	zero configuration			Function" for details
@ 0\r\n	Switch Auto-zero on	@ 0\r\n	@ 0\r\n	See <b>"Auto-Zero</b>
	or off			Function" for details
.\r\n	Returns the scaling	.\r\n	. 00010\r\n	Multiply by 10 in the
	factor multiplier			example
	required to convert			
	the Z or z output to			
	ppm			



#### CO2 LEVEL MEASUREMENT VALUE - Z INFORMATION (0x5A)

Description	Reports the latest filtered CO <sub>2</sub> measurement		
Syntax	ASCII Character 'Z', terminated by 0x0D 0x0A (CR & LF)		
Example	Z\r\n		
Response	Z 00521\r\n		

This value needs to be multiplied by the appropriate scaling factor to derive the ppm value. See the '.' command.

#### CO<sub>2</sub> LEVEL MEASUREMENT VALUE - z INFORMATION (0x7A)

The sensor is also capable of reporting the real time unfiltered CO<sub>2</sub> measurement value.

Description	Reports the unfiltered CO <sub>2</sub> measurement			
Syntax	ASCII Character 'Z', terminated by 0x0D 0x0A (CR & LF)			
Example	z\r\n			
Response	z 00521\r\n			

#### '.' COMMAND (0x2E)

To calculate the measurement value in ppm, the 'Z' or 'z' value, they must be converted into ppm by using the '.' multiplier factor. This multiplier will depend on the full-scale measurement range of the sensor. The multiplier is related to the full-scale range of the sensor.

The multiplier must also be used when sending  $CO_2$  concentration levels to the sensor, for example when setting the fresh air  $CO_2$  concentration value. The '.' Command can also be used to read back the scaling factor.

For example, if the user wants to zero the sensor in a known concentration of gas (e.g. 450ppm), the value written to the sensor must be 450/scaling factor.

Description	Returns a number indicating what multiplier must be applied to the Z $CO_2$				
	measurement output to convert it into ppm.				
Syntax	ASCII character '.', terminated by 0x0D 0x0A ( CR & LF )				
Example	.\r\n				
Response	. 00010\r\n (this number is variable, usually 10)				

Measurement Range of Sensor	CO <sub>2</sub> Measurement Scaling Factor (Z)	CO <sub>2</sub> Measurement Output Units	Example
0 - 60%	10	ppm/10	Z 01200 = 12,000ppm = 1.2%
0-100%	100	ppm/100	Z 01500 = 150,000ppm = 15%



#### **K COMMAND**

The SprintIR<sup>®</sup>-6S has 3 potential modes of operation, controlled by the K command.

Mode	Value	Description	
Mode 0	К=0	Sleep Mode	Sensor is in a SLEEP mode, waiting for commands. No measurements are made. There is no latency in command responses. All commands that report measurements or alter the zero-point settings are disabled in Mode 0. Mode 0 is NOT retained after power cycling.
Mode 1	K=1	Streaming Mode	This is the factory default setting. Measurements are reported twice per second. Commands are processed when received, except during measurement activity, so there may be a time delay of up to 100ms in responding to commands.
Mode 2	K=2	Polling Mode	In polling mode, the sensor only reports readings when requested. The sensor will continue to take measurements in the background, but the output stream is suppressed until data is requested. The sensor will always power up in streaming or polling mode, whichever mode was used before the power cycle.

Command	Use	Default	Range	Example	Response	Comments
K #\r\n	Switches the sensor between different control modes	1		K 1\r\n	K 00001\r\n	See 'K' Commands

### K COMMAND (0x4B)

Description	Sets the control interface mode		
Syntax	ASCII character 'K', SPACE, mode number, terminated by 0x0D 0x0A (CR &		
	LF)		
Example	K 1\r\n		
Response	K 00001\r\n (this number is variable)		



### DIGITAL FILTER COMMANDS

Command	Use	Default	Range	Example	Response	Comments
A ###\r\n	Set value of the digital filter	16	0 – 65535	A 16\r\n	A 00016\r\n	
a\r\n	Return value of digital filter		0 - 65535	a\r\n	a 00016\r\n	

## A COMMAND (0x41)

Description	Set the value for the digital filter		
Syntax	ASCII character 'A', SPACE, decimal, terminated by 0x0D 0x0A (CR & LF)		
Example	A 16\r\n		
Response	A 00016\r\n (this number is variable)		

#### a COMMAND (0x61)

Description	Set the value for the digital filter		
Syntax	ASCII character 'A', SPACE, decimal, terminated by 0x0D 0x0A (CR & LF)		
Example	A 16\r\n		
Response	A 00016\r\n (this number is variable)		



### ZERO POINT SETTING COMMANDS

Command	Use	Default	Range	Example	Response	Comments
F ##### #####\r\n	Fine Tune the zero point		Range of sensor	F 410 400\r\n	F 33000\r\n	See <b>"Zero Point</b> Setting"
G\r\n	Zero-point setting using fresh air			G\r\n	G 33000\r\n	See <b>"Zero Point</b> Setting"
U\r\n	Zero-point setting using nitrogen			U\r\n	U 33000\r\n	See <b>"Zero Point</b> Setting"
u #####\r\n	Manual setting of the zero point			u 32997\r\n	u 32997\r\n	See <b>"Zero Point</b> Setting"
X #####\r\n	Zero-point setting using a known gas concentration		Range of sensor	X 2000\r\n	X 32997\r\n	See <b>"Zero Point</b> Setting"
P 8 ###\r\n P 9 #\r\n	Sets value of CO <sub>2</sub> background concentration in ppm for auto-zeroing	P 8 1\r\n P 9 144\r\n		P 8 1\r\n P 9 144\r\n	P 00008 00001\r\n P 00009 00144\r\n	Two-byte value, P 8 = MSB P 9 = LSB 400ppm in the example
P 10 ###\r\n P 11 #\r\n	Sets value of CO <sub>2</sub> background concentration in ppm used for zero-point setting in fresh air.	P 10 1\r\n P 11 144\r\n		P 10 1\r\n P 11 144\r\n	P 00010 00001\r\n P 00011 00144\r\n	Two-byte value, P 10 = MSB P 11 = LSB 400 in the example

#### F COMMAND (0x46)

Description	Sets the zero-point using a known reading and a known $CO_2$ concentration terminated by 0x0D 0x0A (CR & LF)			
Syntax	ASCII character 'F', SPACE, then the reported gas concentration, SPACE, then			
	the actual gas concentration, terminated by 0x0D 0x0A (CR & LF)			
Example	F 41 39\r\n			
Response	F 33000\r\n (the numbers are variable)			

## G COMMAND (0x47)

Description	Sets the zero point assuming the sensor is in fresh air (typically 400ppm $CO_{2,}$		
	but level can be set by user – see P commands.)		
Syntax	ASCII character 'G' terminated by 0x0D 0x0A (CR & LF)		
Example	G\r\n		
Response	G 33000\r\n (the number is variable)		

### U COMMAND (0x55)

Description	Sets the zero point assuming the sensor is in 0ppm CO <sub>2</sub> such as nitrogen.
Syntax	ASCII Character 'U' terminated by 0x0D 0x0A (CR & LF)
Example	U\r\n
Response	U 32767\r\n (the number is variable)

### u COMMAND (0x75)

Description	Forces a specific zero set point value.	
	Input value is scaled by CO <sub>2</sub> value multiplier, see '.' command.	
Syntax ASCII character 'u', SPACE, then the gas concentration, terminated by 0x		
	0x0A (CR & LF)	
Example	u 32767\r\n	
Response	u 32767\r\n	

#### X COMMAND (0x58)

Description	Sets the zero point with the sensor in a known concentration of $CO_2$ . Input value is scaled by $CO_2$ value multiplier, see '.' command.		
Syntax	ASCII character 'X', SPACE, then the gas concentration, terminated by 0x0D (CR & LF)		
Example	X 1000\r\n		
Response	X 33000\r\n (the number is variable).		

#### P COMMAND - CO<sub>2</sub> Level for Auto-Zeroing

Description	Sets the value of $CO_2$ in ppm used for auto-zeroing.
	Input value is scaled by CO <sub>2</sub> value multiplier, see '.' command.
Syntax	ASCII character 'P', SPACE, then 8, SPACE, then MSB terminated by 0x0D 0x0A (CR & LF)
	ASCII character 'P' then a space, then 9, then a space, then LSB terminated by 0x0D 0x0A (CR & LF)
Example	P 8 0\r\n
	P 9 40\r\n
Response	P 00008 00000\r\n
	P 00009 00040\r\n



The value is entered as a two-byte word, MSB first.

MSB = Integer (Concentration/256) LSB = Concentration – (256\*MSB)

In the above example, target CO<sub>2</sub> background concentration is 400ppm.

MSB = Integer (400/256) = 1 LSB = 400 - 256 = 144

#### P COMMAND – CO<sub>2</sub> Level for Zero-Point Setting

Description	Sets value of CO <sub>2</sub> in ppm for zero-point setting in fresh air.
	Input value is scaled by CO <sub>2</sub> value multiplier, see '.' command.
Syntax	ASCII character 'P', SPACE, then 10, SPACE, then MSB terminated by 0x0D
	0x0A (CR & LF)
	ASCII character 'P', SPACE, then 11, SPACE, then LSB terminated by 0x0D
	0x0A (CR & LF)
Example	P 10 7\r\n
	P 11 208\r\n
Response	P 00010 00007\r\n
	P 00011 00208\r\n

MSB = Integer (Concentration/256) LSB = Concentration – (256\*MSB)

In the above example, target zero-point  $CO_2$  concentration is 2000ppm.

MSB = Integer (2000/256) = 7 LSB = 2000 - (256\*MSB) = 208



#### AUTO-ZERO INTERVALS

UART Command	Use	Default	Range	Example	Response	Comments
@ #.# #.#\r\n	Auto-zero interval settings			@ 1.0 8.0\r\n	@ 1.0 8.0\r\n	See "Auto-Zero Function" for details

#### @ COMMAND (0x2E)

Description	Set the 'Initial Interval' and 'Regular Interval' for auto-zero events.					
Syntax	SCII character '@', SPACE, decimal, SPACE, decimal terminated by 0x0D					
	0x0A (CR & LF)					
Example	@ 1.0 8.0\r\n					
Response	@ 1.0 8.0\r\n (the number mirrors the input value)					

Both the initial interval and regular interval are given in days. Both must be entered with a decimal point and one figure after the decimal point. In the above example, the auto-zero interval is set to 8 days, and the initial interval set to 1 day.

- On this sensor type, auto-zero is disabled by default
- To enable auto-zero, send interval as required @ 1.0 8.0\r\n
- To disable auto-zero, send @ 0\r\n
- To determine the auto-zero configuration, send @\r\n



### PRESSURE AND CONCENTRATION COMPENSATION

UART Command	Use	Default	Range	Example	Response	Comments
S #####\r\n	Sets the pressure and concentration compensation value	8192	0-65536	S 8192\r\n	S 08192\r\n	See "Pressure and Concentration Compensation"
s\r\n	Returns the pressure and concentration compensation value			s\r\n	s 08192\r\n	See <b>"Pressure and</b> Concentration Compensation"

#### S COMMAND (0x53)

Description	Set the 'Pressure and Concentration Compensation' value				
Syntax	ASCII character 'S', SPACE, decimal, terminated by 0x0D 0x0A (CR & LF)				
Example	S 8192\r\n				
Response	S 08192\r\n (the number mirrors the input value)				

### s COMMAND (0x73)

Description	Reports the 'Pressure and Concentration Compensation' value.					
Syntax	ASCII Character 's', terminated by 0x0D 0x0A (CR & LF)					
Example	s\r\n					
Response	s 08192\r\n					



#### **MEASUREMENT DATA OUTPUTS**

The sensor can send multiple fields of data as a single string. Up to five data fields can be transmitted, programmable by the user. The number of fields and the type of data to be transmitted is defined by the "Mask Value" setting.

The output data format is as follows. Each field is identified by the Data Field Identifier character, followed by a space, followed by the five-digit number indicating the value of the parameter.

Data Parameter	Data Field	Mask	Description
	Identifier	Value	
D digitally filtered	d	2048	Reports a value related to the normalized
			LED signal strength (smoothed)
D unfiltered	D	1024	Reports a value related to the normalized
			LED signal strength
Zero Set Point	h	256	Reports a value related to the normalized
			LED signal strength
Sensor Temperature	V	128	Reports a value that varies inversely with
(unfiltered)			the sensor temperature.
LED Signal (digitally	0	32	Reports a value that gives an indication of
filtered)			the LED signal strength (smoothed)
LED Signal (unfiltered)	0	16	Reports a value that gives an indication of
			the LED signal strength.
Sensor Temperature	v	8	Reports a value that varies inversely with
(filtered)			the sensor temperature. (smoothed)
CO <sub>2</sub> Output (Filtered)	Z	4	Filtered CO <sub>2</sub> reading
CO <sub>2</sub> Output	z	2	Raw CO <sub>2</sub> reading, unfiltered
(Unfiltered)			

UART Command	Use	Default	Range	Example	Response	Comments
M #####\r\n	Sets the number of measurement data types output by the sensor. ##### is the mask value	M 00006\r\n		See <b>"Output</b> Fields"	M #####\r\n	Sets the number of measurement data types output by the sensor

The required mask value is the sum of the 'Mask Value' for each field required. To output filtered and unfiltered  $CO_2$  data, set M=6. Due to the sensor speed, no more than two output fields should be selected.



#### **M COMMAND**

Description	Sets the type and number of data outputs				
Syntax	SCII character 'M', SPACE, up to 5 digit number, terminated by 0x0D 0x0A				
	(CR & LF)				
Example	M 6\r\n				
Response	M 00006\r\n				

#### **Q COMMAND**

Description	Reports the latest output data fields, defined by 'M'			
Syntax	ASCII character 'Q', terminated by 0x0D 0x0A (CR & LF)			
Example	Q\r\n			
Response	Z 00010\r\n			

#### SERIAL NUMBER AND FIRMWARE VERSION

UART Command	Use	Default	Range	Example	Response	Comments
Y\r\n	Return firmware version and sensor serial number			Y\r\n	Returns <u>two</u> lines	

#### Y COMMAND (0x59)

Description	The present version string for the firmware and serial number of the sensor.			
Syntax	ASCII character 'Y', terminated by 0x0d 0x0a (CR & LF)			
Example	Y\r\n			
Response	Y,Aug 25 2021,14:19:56,LP15132			
	B 528148 00000			
	Where;			
	Aug 25 2021,14:19:56 is the firmware compile date and time			
	LP15132 is the firmware revision			
	528148 is the sensor ID			

N.B. This command returns two lines split by a carriage return line feed and terminated by a carriage return line feed. This command requires that the sensor has been stopped (see 'K' command).



### CONNECTION DIAGRAM FOR UART INTERFACE





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# SprintIR<sup>®</sup>-6S

# High Speed CO<sub>2</sub> Sensor

### **REVISION HISTORY**

DATE	RELEASE	DESCRIPTION OF CHANGES	PAGES
16/04/2020	4.0	First revision	All
13/05/2020	4.1	Updated auto-zero language, updated	All
		parametric measurement limits	
10/06/2020	4.2	Absolute Maximum Ratings, Mechanical	P.7
		Sealing	
21/07/2020	4.3	Package Drawing	P.5
21/09/2020	4.4	Added 10% option	P.4, P.8
18/11/2020	4.5	Absolute Maximum Ratings	P.7
19/01/2021	4.6	'.' COMMAND (0x2E)	P.21
01/02/2021	4.7	ABSOLUTE MAXIMUM RATINGS	P.7
11/06/2021	4.8	Updated T90 response times	P.8, P.10
23/06/2021	4.9	@ COMMAND UPDATE	P.26
18/08/2021	4.10	Added Data Field Update	P.28
27/09/2021	4.11	Y Command	P. 29
08/12/2021	4.12	Various minor corrections	All