





## Integrated IR FEATURES

- Triple Range (0%-1%v.v, 1%-4%v.v, 4%v.v&above) Gas Sensor with Automatic Switchover between ranges.
- High Resolution up to 35ppm and Detectivity Level as low as 100ppm.
- Digital and Analog Concentration Output:
  - I. Completely Linearized Concentration
  - II. Temperature Compensated (-20°C to 75°C)
  - III. Condensation Compensation Algorithm
  - IV. Humidity Compensated Concentration
  - V. 100ppm Precision & Repeatability Error
- Internal Temperature digitally transmitted via UART
- Active & Reference Signals Monitored digitally transmitted values via UART
- Full Faults Diagnostics & Error Generation
- Cyclic Redundancy Check (CRC)
- Three Different Modes of Operation
- Automatic Thermal Shutdown Function
- Automatic Overcurrent Protection Function
- Advanced ESD ±30kV (IEC 61000-4-2) Protection
- Typical Low power consumption < 32mA (Average)
- Factory calibrated for Methane or Carbon Dioxide or if required for various other ranges or gases
- 24-bit Analog to Digital Converter (ADC)
- 14-bit Digital to Analog (DAC) output
- Evaluation Kit available including PC software for easy testing and production calibration functions
- Easy implementation into Sensors Network
- Design for use in Hazardous Areas
- Certified Sensor for use in Explosive Atmospheres (EX)

## **RECOMMENDED APPLICATIONS**

- Mining
- Automation & Control
- Indoor Air Quality
- Industrial Health & Safety

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# **Integrated IR Datasheet**

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#### **GENERAL DESCRIPTION**

The Integrated IR (INIR) sensor has been designed with the latest technology, using a microcontroller with an ARM7TDMI core and via software design the necessary techniques have been implemented to increase the reliability of the device therefore minimize the probability of faults. The INIR is a user friendly digital Gas Sensor, which is designed to use the latest SGX Sensortech's Infrared technology. The sensor is designed to decrease the implementation time therefore increase productivity. The Integrated IR sensor incorporates the necessary electronics and embedded software to operate from a low voltage DC power supply. The sensor will process the raw signals to output a linear, temperature compensated signal proportional to the gas concentration applied. The output signal is available in digital and analogue forms.

The SGX Sensortech Integrated IR Gas Sensor provides users with a simple method of incorporating an Infrared Sensor into their gas detection instrument which will significantly reduce the development time and expertise required during the design and implementation phase. The Integrated IR can also be factory calibrated to allow installation without the need for recalibration.

## PRINCIPLE OF OPERATION

The core technology used incorporates a very wellknown and proven to work NDIR Gas Sensing technique together with a robust, highly reliable ARM7 MCU mounted on a high performance printed circuit board. The INIR has been designed as an improved digital version of the 7-pin single gas like the IR12GM\_1 gas sensor, which contains supported lamp for additional shock protection. The necessary electronic circuit and embedded firmware will calculate the linearized and temperature compensated concentration via Digital (32-bit) and Analog (14-bits) outputs. The Configuration Unit can be used to set up, calibrate and evaluate the INIR with easy-to-use PC software.

Alternatively, control of the INIR via UART is available for communicating with an external microprocessor as well. The device contains full fault diagnostics, which are sent via the Digital String along with the Temperature output of the sensor and the linearized Concentration in parts per million (ppm).



## **TECHNICAL SPECS & MAXIMUM RATINGS**

Power Supply	Min	Typical	Max	
Supply Voltage	3.2 VDC	3.3 VDC	5.0 VDC	
(with Tolerances)	(+5%)		(+/- 5%)	
Average Current	30mA	32mA	35 mA*	
Consumption	*Inrush Current can be up to 65mA			
Logic Outputs Level	LOW Voltage Level(VOL) : 0.6V Maximum HIGH Voltage Level(VOH): 2.0V Minimum 1.6mA source current maximum			
Logic Inputs Level	LOW Voltage Level(VINL): 0.4V Maximum HIGH Voltage Level(VINH): 2.0V Minimum			
Humidity				
<b>Operating Humidity</b>	0%	50%	99%	
Storage Humidity	0%	50%	90%	
Condensation (>100% Humidity)	Sensor's Detection Limit, Stability & Linearity would be affected, algorithms are implemented to minimize as the effect.			
Temperature				
Operating Temp.	-40 °C	+20 °C	+75 °C	
Storage Temp.	-20 °C	+20 °C	+55 °C	
Temp. Cycle Limits		0.8 °C/min	1.3 °C/min	
Pressure (Compensa	tion will be	required )		
<b>Operating Pressure</b>	80kPa	-	120kPa	
Storage Pressure	80kPa	-	120kPa	
Performance				
ADC Resolution	-	24-Bit	-	
DAC Resolution	14-Bit at 0.0	-2.5 Volts DC	Max	
	Scalable according to Gas Conc.			
	Operating Range			
<b>D:</b> ·	I <sub>max</sub> = 0.5mA	on 5K Resistiv	/e Load	
Dimensions	10.0	20	20.4	
Diameter (D)	19.9mm	20mm	20.1mm	
Height (H)	16.50mm	16.60mm	16.70mm	
Pins Height (pH)	4.0mm	4.8mm	5.6mm	
Body Material	Stainless Steel			
Weight (gr)	25 gr.	29 gr.	33 gr.	
Gas Sensor Sockets				
S1	6-Pir	n , Polygon To	pology	

## WARRANTY VALIDITY & PRECAUTIONS

Warranty period or any extended warranties would be confirmed with the order confirmation.

The warranty is invalidated if the sensor is used under conditions or specifications other than those indicated in this datasheet or/and the sensor has been custom modified.

Stresses above maximum limits may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

SGX Sensortech (IS) Ltd maintains the right to modify or remove any specifications within this document at any time without warning.

#### **ESD CAUTION**

ESD (Electrostatic Discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary subjected circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degration or loss of functionality.

Warning! Plugging or Unplugging the Sensor while in operation may damage the device beyond repair. Always power down the instrument when performing maintenance.



## HANDLING PRECAUTIONS

- A. Do not drop the Integrated IR on the floor as this could cause damage to the pins or internal components.
- B. Avoid mechanical force against pins or sockets. Protect from dust and sprayed acidic particules.
- C. Do not immerse in water or other fluids.
- D. Do not solder the module directly onto a pcb or wires. Excessive heat could cause damage.

## **ROHS COMPLIANCE**

Under the EU Directives, compliance testing is necessary for Pb, Cd, Hg, Cr (VI) and Br. The RoHS directive is effective

since July 1, 2006. The regulations prohibit the use of these hazardous substances in new products sold after July 2003.



## WEEE DIRECTIVE

WEEE (Waste from Electrical and Electronic Equipment) is a directive that controls how electric and electronic equipment is handled and recycled effective since August 13, 2005. INIR clustered as component and SGX do not need

to have a recycling scheme in place but manufacturers may need to ensure WEEE compliance for their instruments or systems.



## ATEX/IECEx CERTIFICATIONS

The ATEX directive consists of two EU directives describing what equipment is allowed in an environment with an explosive atmosphere. The Integrated IR is certified for ATEX (Sira 99ATEX1121U) and IECEx (Sira 04.0031U), see page 5 for more details.

II 2G Ex db IIC Gb Ta -40°C to +75°C

## SIL RATING

Safety Integrity Level (SIL) is defined as a relative level of

risk-reduction provided by a safety function, or to specify a target level of risk reduction

The INIR doesn't need to be SIL rated for customers to use it in portable instruments or a fixed system; the

same may not apply for the system itself. INIR is not SIL rated.



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## PIN CONFIGURATIONS & DIMENSIONS



Pin Name Description TXD Transmitted data via UART from the Integrated IR. Connect this to your RXD pin. 1 2 +VCC 3.2 Volts – 5.0 Volts DC input to Integrated IR 3 GND GND Plane, 0 Volts reference for Integrated IR Received data via UART for the Integrated IR. Connect this to your TXD pin on your MCU. 4 RXD 5 OUT Analog Output. Scalable range, see Application Note 1 Integrated IR Protocol & Calibration for details. P1 Ρ1 Bootloader Pad. Not used by the customer. NOTE1: All Dimensions in mm. All tolerances Linear +/- 0.1mm and Angular 0.5° unless otherwise stated, see also page 2. NOTE2: Customer needs to make sure to find the correct "sockets" for the Gas Sensor to firmly "push fit" plug into their instrument so correct electrical connection is achieved, also see handling precautions in page 2.

#### **DESIGN CONSIDERATIONS & APPLICATIONS**

The following guidelines are here to help the correct implementation of the INIR into an Instrument. SGX has no responsibility if you wrongly or not at all implement the recommended techniques below and as a result you damage your equipment or the sensor.

**Power Supply and Hazardous Applications** 

- It is advisable to limit current with a 125mA Intrinsic Safety (I.S.) FUSE 1 (e.g. Littelfuse 0259.125). This will allow 125mA x 1.7 Ohms= 212.5 mA max (see Figure 1). The FUSE1 meets the Barrier Network Standards EN50020 and the EN60079-11 for hazardous applications. Using a fuse may drop the voltage; make sure the input voltage used is within <u>specifications</u>.
- It is recommended to protect for over-voltage with duplicate (ib) or triplicate (ia) zener diodes. Assume typical 5v1, 5% triple zeners (see Figure 1, D1, D2, D3), the power is limited to 1.14W max. This meets the Pi rating for the circuit of INIR (1.5W max.).
- Keep any tracks protected with double printed solder mask, exposed cables shielded and firmly attached onto terminal blocks, even if you are not using them. Loose cables can create short-circuits that will damage the equipment or ignite a gas.
- 4. The Integrated IR has a 5V TVS Diode but *no fuse* internally. Incorporates thermal shutdown at 150°C and overcurrent protection at 150mA-200mA.
- 5. The module includes protection for ESD ±30kV (IEC 61000-4-2) clamping from lighting or human body.
- 6. INIR is certified for use in Explosive Atmospheres (EX). Please see Fig. 1, for an example.

#### Warm-Up Time

The Warm-Up Time for the INIR is around 45 seconds after each power "ON" or every time we are changing from Configuration to Normal/Engineering Mode. The "Warm-Up" time is not including the period that the sensor needs to reach the ambient temperature. The time needed for the sensor to stabilize is directly related to the Pyroelectric Detector. The sensor though is capable of producing readings during the Warm-Up but with a much higher error than specifications. It is recommended to ignore completely the reading on the first 1 minute after power ON or a change from Configuration to Normal/Engineering Mode. Calibration

For calibration process please read the appropriate Application Note 1, "Integrated IR Protocol & Calibration". For optimum performance please use following cylinders:

• • • •	• •			
INIR-ME100%(Methane)	INIR-CD5.0%(Carbon Diox)			
100% Nitrogen for Zero calibration				
20.0% CH <sub>4</sub> for High Span Cal.	5.0% CO <sub>2</sub> High Span Cal.			
2.0% CH <sub>4</sub> for Offset Cal.	2.0% CO <sub>2</sub> for Offset Cal.			

Always do Zero Calibration first followed by High Span and only if needed the Offset Calculation.

#### **Gas Flow Rate**

For valid evaluation and to keep tests consistent it is recommended to use 450 – 500 cc/min. flow rate to minimize any effects due to pressure variations in the INIR. Faults Monitoring/Error States

The Error monitoring and Fault generation happens every second transmitted via the UART in the same digital string. Regularly check all the Faults generated from the INIR to ensure errorless communication and rise appropriate alarms depending on the Fault code. For further information on the different Faults and how to translate them, read the Application Note 1, "Integrated IR Protocol & Calibration".

#### **Digital Interface/Communication**

In the Figure 1 we can see an example for reading correct the Analogue output and the Digital output string of data transmitted by the Integrated IR.

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In terms of the Software implementation, we will need a way to read the Digital Output or the Analogue Output by using a Microcontroller (MCU) or a Personal Computer (PC) is required. The Software with the Evaluation Kit is compatible with Windows Operating System only and at the moment is not possible to read the Analogue output by using the Evaluation Software.

#### **Communication in Network/Long Distances**

Using the Integrated IR in a network of sensors is possible but we will need an expansion board attached to the Integrated IR to extend distance and guarantee the errorless connection between the Integrated IR Sensor and the customer's device. The Universal Asynchronous Receive/Transmit (UART) protocol cannot be transmitted into long distances without converting it into a Network Communication Protocol, therefore to increase the reliability please keep the length of the connection short away from strong electro-magnetic fields.

#### **Analogue Output**

The Analogue Output is updated every second by the same time and rate with the Digital String. The Analogue voltage is coming from a Digital to Analog Converter (DAC) and is directly related with the Concentration

#### ESD/EMI/RF Shielding

The component includes protection for ESD  $\pm 30$ kV (IEC 61000-4-2) clamping from lighting or human body. According to the relevant regulation for components and subassembles and because SGX is not selling directly to the enduser, the INIR has not been tested for Electromagnetic Compliance (EMC). The incorporation of the component to an apparatus could result within the scope when placed on the market and/or put into service. It is manufacturer's liability to comply with regulations in their country. If required for the sensor to be used next to strong electromagnetic fields or RF interferences please consider using specially designed RF/EMI shielded enclosure to protect the sensor and the rest of the instrument as well. Condensation, Dust & Extreme Conditions

Using the INIR in extreme environmental conditions may affect its performance. Typically the module has a high corrosion resistance and temperature compensated linearized output. The INIR implements an Condensation Compensation Algorithm to minimize the effect especially after power "ON", eliminating the problem with false alarm. The Sensor can withstand multiple thermal shocks that don't exceed 1.3°C/min temperature slopes. In applications like mining where dust or other particles are present is recommended to use a dust filter firmly attached to the inlet of the INIR Gas Sensor. The filter tends to increase response times T90, T10 and T50 therefore ensure correct installation and evaluation to comply with regulations in your country. If your device is intended to be used in a hazardous environment please seek advice from a certification body. **Pressure Compensation** 

The INIR will definitely need pressure compensation irrelevant if the pressure is within the operating pressure. Re-Zero the INIR Gas Sensor under operating conditions is recommended; this will minimize the pressure effects, temperature differential effects but will not eliminate the weather effects like extreme wind velocity, rain or lighting. Three Ranges/Automatic Switchover

The INIR implements an automatic switchover between three ranges, LOW(0.0%v.v-1.0%v.v), MID(1.0%v.v-4.0%v.v), High(4.0%v.v & above). When needed individual coefficients are used for each range improving precision, resolution and linearity based on default factory calibration.



Fig. 1 -Example schematic for Interfacing Integrated IR (INIR)

## FURTHER APPLICATIONS NOTES & TECHNICAL INFORMATION

For detailed information and application notes please read the Integrated IR Application Note 1, "Integrated IR Protocol & Calibration". In there you can find instructions on how you can communicate with the Integrated IR Sensors and perform several functions like Zero and Span Calibration. You can also find and download all the related datasheets and applications notes online on our web-site at: <u>SGX Sensortech (IS) Ltd</u> (<u>www.sgxsensortech.com</u>) or contact our region sales office depending on the country you are. The current datasheet is available in two different languages, English and Chinese, please specify the correct version you want when you are contacting our sales department or downloading it online.



## **TYPICAL PERFORMANCE CHARACTERISTICS**

(All Characteristics are related to a calibrated sensor and conditions, Temperature 20°C, Relative Humidity 10%RH, Pressure 101kPa, 500 to 1000 ml/min Gas Flow, Averaging of 13 values, unless otherwise stated.)

Test	INIR-ME100%	INIR-CD5.0%		
Stabilisation or Warm-up Time (EN)	0%v.v ±0.1%Vol in 1 minute	0%v.v ±0.01%Vol in 1 minute		
Calibration Curve (EN)	0 to 100%v.v -> 0.06%v.v	0 to 5%v.v-> 0.06%v.v		
or Basic Error (AQ)	or $\pm$ 6% of Reading whichever is greater.	or $\pm 6\%$ of Reading whichever is greater.		
Short Term Stability (EN)	0%v.v = ±0.005%v.v	0%v.v = ±0.002%v.v		
of the Displayed Value(AQ)	100%v.v = ±1%v.v	5%v.v = ±0.05%v.v		
Minimum Resolution (AO)	From 0 to 5%v.v -> ±0.002%v.v	From 0 to 2%v.v -> ±0.004%v.v		
Winning Resolution (AQ)	From 5 to 100%v.v -> ±0.1%v.v	From 2 to 5%v.v -> ±0.01%v.v		
Long Term Stability (EN)	0%v/v = ±0.01%v.v / Month	0%v/v = ±0.05%v.v / Month		
or Working Stability (AO)	$5\% v/v = \pm 0.1\% v.v / Month$ $2\% v/v = \pm 0.05\% v.v / Mont$			
	100%v/v = ±1.5%v.v / Month 5%v/v = ±0.1%v.v / Month			
Temperature Error (with	0%v.v to 5%v.v = ±0.05%v/v	0%v/v to 2%v.v = ±0.01%v.v		
Compensation)	5%v.v to 20%v.v = ±0.2%v.v	2%v/v to 4%v.v = ±0.02%v.v		
(-20°C to +60°C, relative to 20°C)	20%v.v to 100%v.v = $\pm$ 2%v.v	4%v.v to 5%v.v = ±0.05%v.v		
Pressure (with Compensation)	±0.07%Vol or ±7%	±0.07%Vol or ±7%		
(50kPa-130kPa, relative to 100kPa)	of the reading	of the reading		
Humidity Error	0%v.v = ±0.05%v.v	$0\%y/y = \pm 0.01\%y/y$		
(10% RH to 90% RH relative to 45% RH)	$5\%v.v = \pm 0.1\%v.v$			
(10/0/// 10 50/0///) / Plative to 45/0///	100%v.v = ±1.5%v.v	576474 - ±0.05764.4		
Response Time *1	Typ. T <sub>90</sub> ≈ 18 sec, Average 12	Typ. T <sub>90</sub> ≈ 18 sec, Average 12		
(without dust filter)	Max $T_{90} \approx 30$ sec, Average 20	Max $T_{90} \approx 30$ sec, Average 20		
Power Supply Variations	The Performance of the INIR is not affected by power supply variations as long as the			
(at ±5% of Nominal Voltage)	power supply provides DC Regulated voltage according to specifications.			
Power Supply Rejection Ration (PSRR)	at 1 MHz -> 50 dB at 100 kHz -> 68 dB at 10 kHz -> 99 dB			
(at ±5% of Nominal Voltage)	at 1 MIN2 -> 30 UD , at 100 KN2 -> 00 UD , at 10 KN2 -> 88 UB			
Tomporature Cycling or Pamping Duift	0%v/v = ±0.05%v.v	$0\% v/v = \pm 0.05\% v.v$		
(Maximum at $1.3^{\circ}$ C/min )	5%v/v = ±0.2%v.v	2%v/v = ±0.1%v.v		
	100%v/v = ±3%v.v	5%v/v = ±0.25%v.v		
Thermal Shock Drift	0%v/v = ±0.05%v.v (max)	0%v/v = ±0.05%v.v (max)		
Uncertainty Error of Calibration	±0.15% Error of the Actual Reading	±0.15% Error of the Actual Reading		
NOTE: All data and tests are relating to EN 60079-29-1 and AQ 6211, European and Chinese standards.				

## **CERTIFICATIONS DETAILS**

	ATEX	IECEx				
Certificate	Sira 99ATEX1121U	IECEx SIR 04.0031U				
Standards	EN 60079-0:2012, IEC 60079-1:2014 Ed. 7	IEC 60079-0:2011 Ed.6, IEC 60079-1:2014-06 Ed.7				
	II 2G					
Product Marking	Ex db IIC Gb	Ex db IIC Gb				
	Ta -40°C to +75°C					
	Power Input: 1.5W Maximum	Ambient temperature range: -40°C to +75°C				
	<b>Condition 1:</b> The thermal resistance of the Gas Sensing Heads do not exceed 25K/W. This shall take i account when considering its surface temperature and the temperature classification of the equipment i					
	which it is to be incorporated. Tests indicated that an internal ignition raises the temperature of the mesh b					
	further 4.2K (including a 1.2 safety factor). <u>Condition 2:</u> The Gas Sensing Heads shall be protected from impact in service. The Gas Sensing Head shall be					
Special Conditions for						
Safe Use	mounted in a protective enclosure such that an impact of 7 J in accordance with IEC 60079-0:2007 clause					
	26.4.2 from any direction shall not cause the impact head to make contact with the Sensing Head.					
	Condition 3: The Gas Sensing Heads are dust-proof (IP5X) but offers no protection against the ingress of					
	water. Where protection in excess of IP50 is required, then the apparatus into which the Gas Sensing Head is					
	installed shall provide the necessary ingress protection (for example by fitting an external semi-permeable					
	membrane).					
Manufacturing &	SGX Sensortech(IS) Ltd, 2 Hanbury Road, Widford Industrial Estate,					
Certificate Address	Chelmsford, Essex, CM1 3AE, UK					



## **TYPICAL PERFORMANCE DATA**

(All Data are related to a calibrated sensor and conditions: Temperature 20°C, Relative Humidity 10%RH, Pressure 101kPa, 500 to 1000 ml/min Gas Flow, Averaging of 13 values, unless otherwise stated.)

#### **GENERAL PERFORMANCE**





Fig. 2 – Warm Up, 20°C, 10% Rh, 1 atm. Aver. 10 secs

#### Typical ESD Effect (around +12kV, Human Body Model)



Fig. 3 – Effect Around +12kV ESD (Human Body Model)

## **PERFORMANCE DATA for METHANE (INIR-ME)**

## Short Term Precision/Stability





Fig. 5 – Precision/Stability at 0.00% Methane

#### Typical Linearity 0-100%v.v Methane



Fig. 6 – Typical Linearity Variations in 20 Sensors



Fig. 7 – Typical Linearity 0-5% Methane



#### Typical Response Time T90 Timing without Dust Filter





## Typical Absorbance Methane (Batch of 20)



Fig. 9 – Typical ME Absorbance Batch of 20 Devices

## PERFORMANCE for CARBON DIOXIDE (INIR-CD)

**Typical Short Term Precision/Stability** 



#### Fig. 10 – Typical Stability under 3.0% Carbon Dioxide

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#### **Typical Linearity 0-5% Carbon Dioxide**





#### Typical Response Time T90 Timing without Dust Filter



Fig. 12 – Typical T90 without Dust Filter, Averaging 10, 5% Applied Carbon Dioxide



#### Typical Absorbance Carbon Dioxide (Batch of 20)

Fig. 13 – Typical CD Absorbance Batch of 20 Devices



## Appendix A Table of Coefficients

Please read the applicable Integrated IR Application Note (AN1\_Integrated IR Protocol & Calibration) for the correct ranges and the coefficients depending on the version of the Firmware that your Integrated IR Module is utilizing. Always make sure you are using the correct coefficients as the performance of the Integrated IR would be affected by those values. The Integrated IR by default is factory calibrated and containing the best fit for performance optimization of the coefficients, therefore be careful when you try to change them to something else. Please ask SGX for more details if you are not comfortable with calculating your own coefficients or best use the default included.

## NOTE:

1. These coefficients are based upon results measured at SGX Sensortech (IS) Ltd using standard test equipment. These coefficients may vary slightly when using different circuits. It may be required to recalculate some of these coefficients if small inaccuracies are observed during testing (refer to Infrared Sensor Application Note 5 for determination of coefficients).

2. The coefficients are representing the average typical coefficients that the customer's can use for evaluation. SGX Sensortech (IS) Ltd is making sure for all the internal calibrations to recalculate and check the coefficients for best fitting the individual characteristics of each sensor.





Ordering Code	Methane Detection	Carbon Dioxide Detection	Standard Calibration	
INIR-ME100%	YES	NO	0-100%	
INIR-CD5.0%	NO	YES	0-5%	
Evaluation Kits				
INIR-EK4	-	-	Just the Eval. Kit no sensor	
Note: When ordering an INIR Evaluation Kit please order the Sensor that you want to evaluate; in the kit is not included				
a gas sensor unless you ask for it. Not all concentrations are available with all gases.				
*1 The default calibration for Methane if 0-100% Full Range and for Carbon dioxide is 0-5% Full Range.				
*2 For special samples or other target gas please contact SGX Sensortehc (IS) Ltd or your regional sales office in your country.				

#### **Contact Details**

For further information and technical support for the product please contact SGX Sensortech (IS) Ltd using the following contact details:

#### **Headquarters United Kingdom**

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Created & Printed in the Essex, United Kingdom by SGX Sensortech (IS) Ltd.