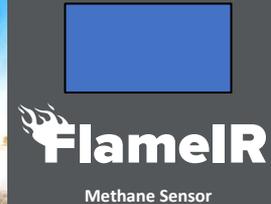
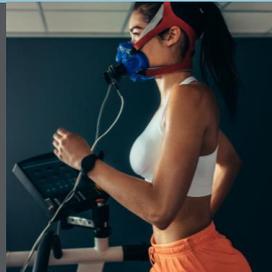


Gas Sensing Solutions Ltd

FlameIR-ME1 Methane Sensor Product Presentation





Leading designer and manufacturer of advanced optical gas sensors



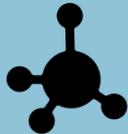
Unique vertically integrated capability, with in-house manufacturing of infra-red light emitting diode (LED) sources, enabling GSS to create the world's lowest power and highest speed advanced infra-red LED optical gas sensors



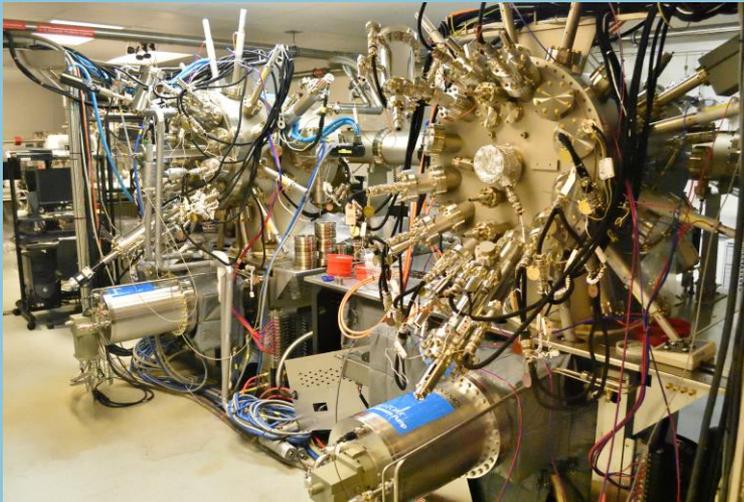
Global footprint with world-wide network of direct sales, distributors and representatives, providing expert customer support



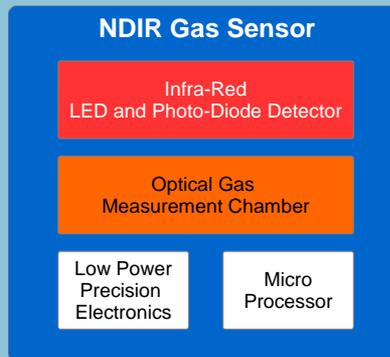
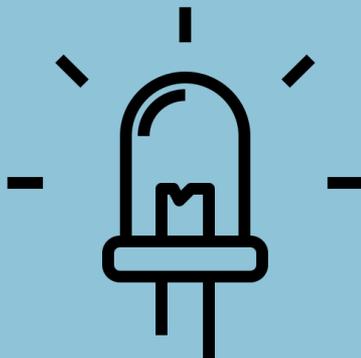
GSS gas sensors are used by leading OEMs in a diverse range of applications including **medical, safety, environmental, agricultural and industrial applications** to detect and control pollutant, hazardous or health indicator gases



State-of-the-art CO₂ and CH₄ NDIR family of gas sensors delivering world-class accuracy, responsiveness and power consumption



- **World's only independent gas sensor company** to manufacture exotic infra-red LEDs in-house, allows us to **optimise LED performance** for our gas sensors
- **Rich history of innovation and industry first's** in CO₂ gas sensors – now being applied to the methane sensor market
- Built-on **>15 years of experience** in infra-red LEDs, sensor optics, low power electronics and gas testing
- Vast experience of end-applications and sensor optimisation



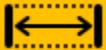
Established Business

- >10 years shipping sensors
- >1500 Customers
- Sold >25 Countries

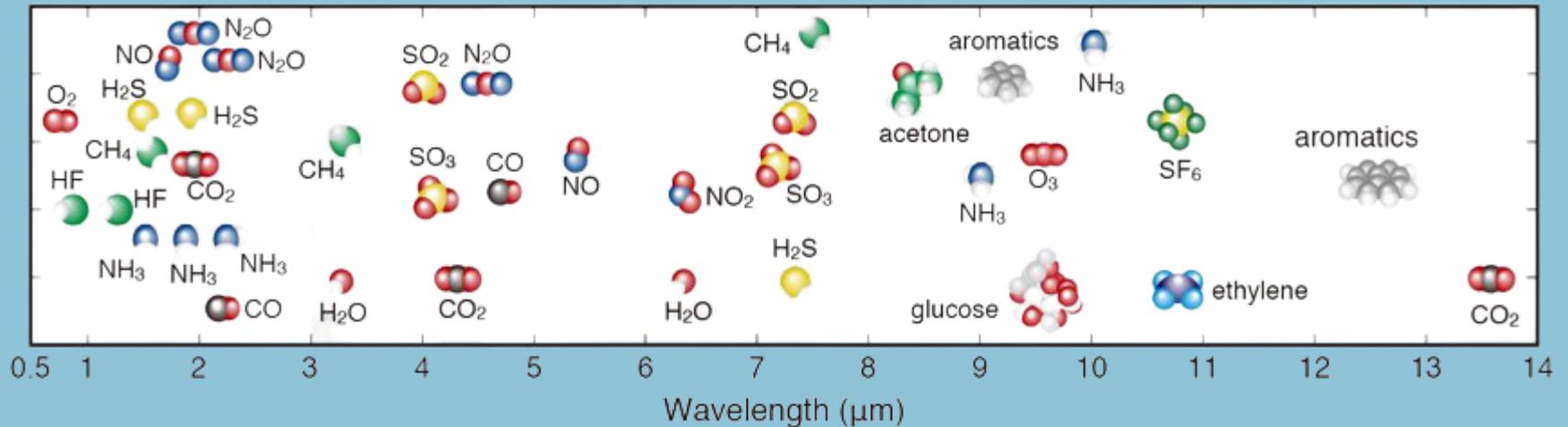
Rich Technology

- 4 Patents
- 4 Product Families
- 100+ Man Years Experience of Gas Sensing

Leverage in-house LEDs, optimised for our advanced gas sensors, backed up by world-class IP in optics, gas sensor design, low power electronics and production gas testing

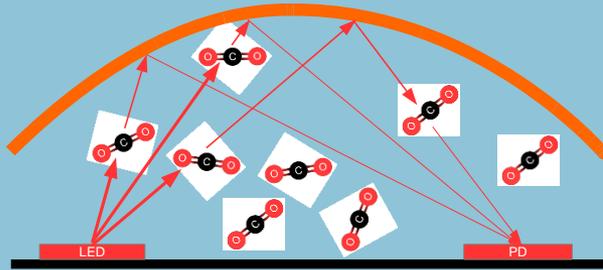
Desirable Attributes	Power Consumption 	Responsiveness/Speed 	Dynamic Range 	Multiple Gases 	Robust and Long Life 	Easy to Use 
GSS Solid-State Infra-Red LED	Intrinsically efficient at converting electrons to photons – always low power	Measurements done at the speed of light, limited only by companion electronics	Capable of measuring from parts per billion to 100%	Can detect CO ₂ , CO, N ₂ O, NH ₃ (ammonia), C ₂ H ₄ , (ethylene), CH ₄ (methane) and other similar carbon based flammable gases	Insensitive to temperature, humidity and vibration, very long operating life, do not wear out or degrade	Immune to poisoning by contaminant gases
Other Traditional Types of Gas Sensor Technology (infrared lamp, chemical, pellistors, photo-ionisation)	Use lots of power – incompatible with emerging need for battery powered wireless devices	Slow to respond to changing gas levels - incompatible with emerging needs, particularly medical	Poor dynamic range, and poor accuracy in real-world applications	Typically specific to one gas type - not easily adapted	Often degrade over time, requiring expensive and time consuming maintenance, or replacement	Easily poisoning by other contaminant gases

GSS optical infra-red sensors the best technology for flammable gas detectors, and in-house manufactured LEDs give GSS a performance and cost advantage



- Gases absorb light energy at different wavelengths, depending on the chemical bonds in the gas
- The amount of energy absorbed by the target gas is proportional to the concentration
- LEDs can be tuned to generate different wavelengths, to specifically target the gas on interest

LED NDIR Technology



- Infra-Red Light is Absorbed by Gas Molecules
- Absorption Proportional to Concentration

GSS Gas Sensor

NDIR Gas Sensor

Infra-Red
LED and Photo-Diode Detector

Optical Gas
Measurement Chamber

Low Power
Precision
Electronics

Micro
Processor

GSS Vertical Integration

- Unique In-House Manufactured LEDs and PDs



Unique Skills Base

- Optimised LEDs and PDs, Grown In-House
- World-Class Optical Design Skills
- Low Power Embedded Software and Precision Electronics Expertise
- >10 years of Acquired Experience of Gas Sensor Development and Production

Gas Chamber

- In-house optical path design, typically manufactured in polycarbonate plastic
- Gold coated for superior long term reliability and optical efficiency

Solid State LED Technology

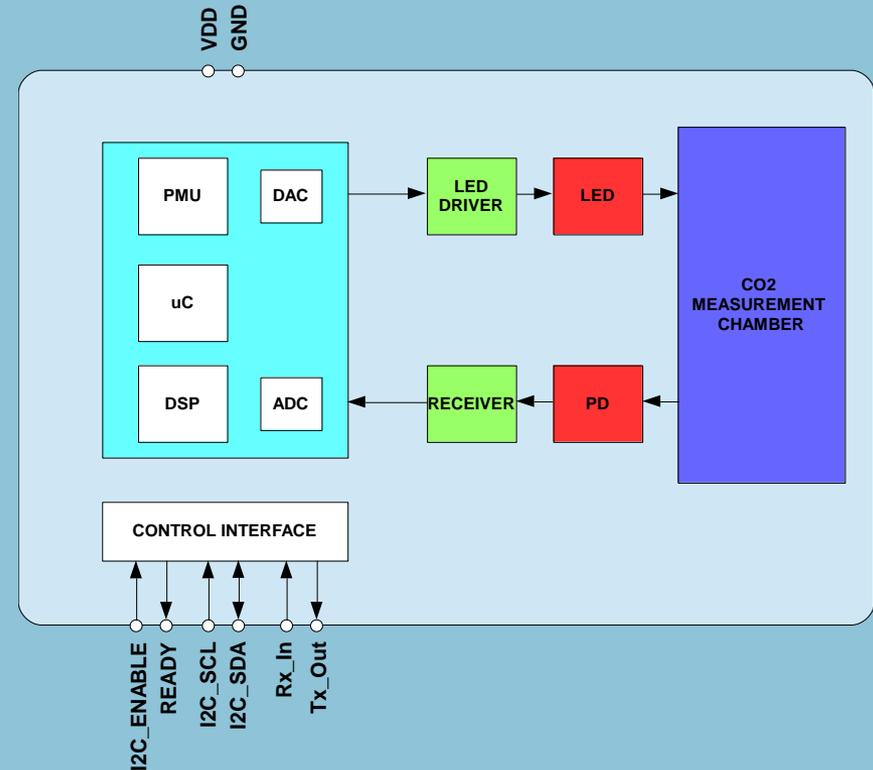
- Solid state LED light source and photodiode detector, manufactured in-house

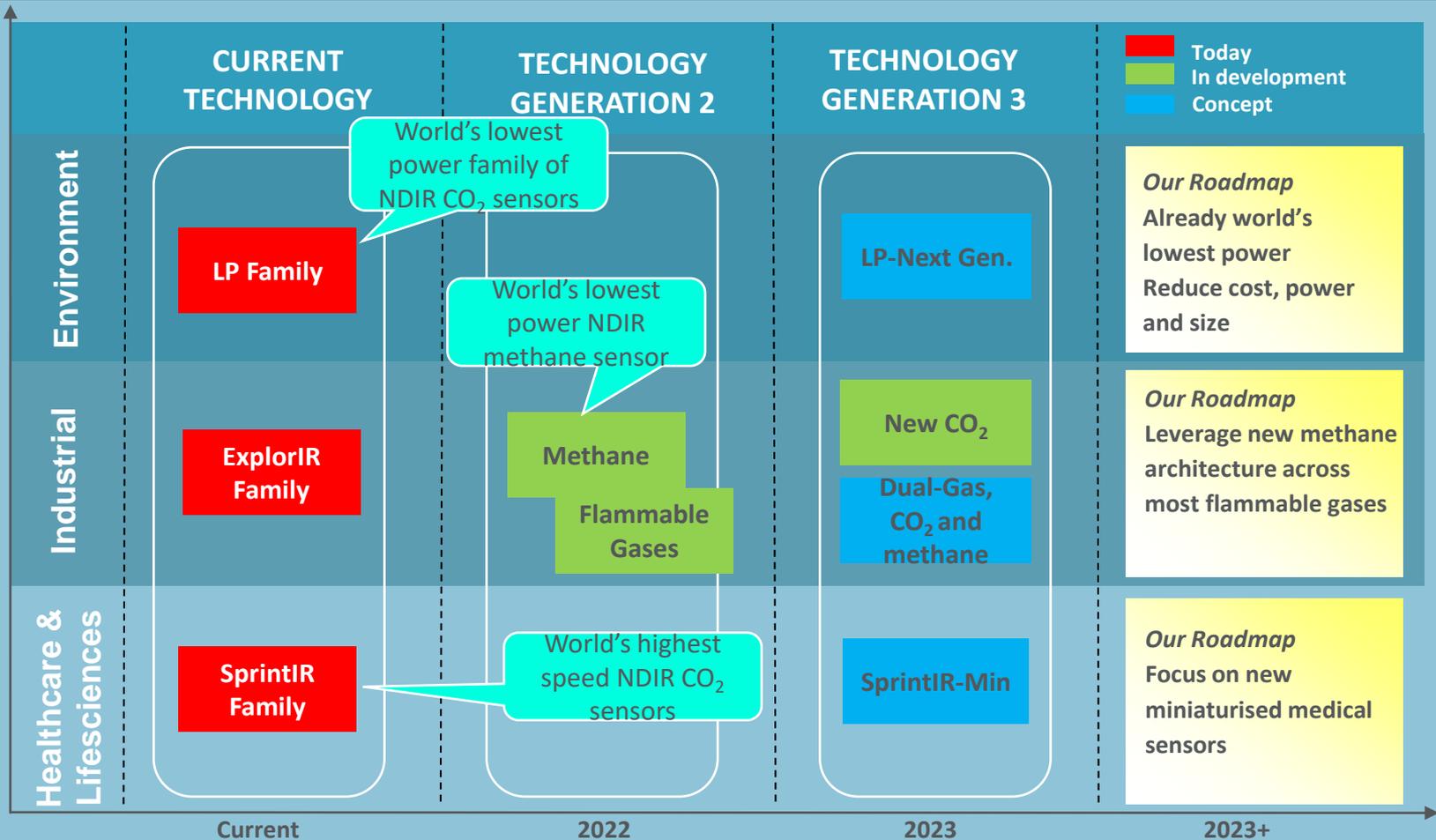
Optics Interface Electronics

- Low noise and low-power analogue

Embedded Microprocessor, memory and PMU

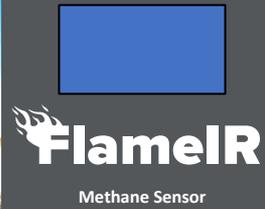
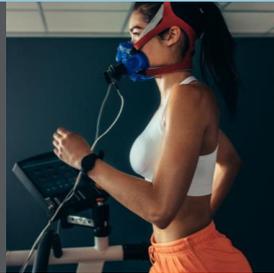
- Low-power focused





GSS roadmap leverages new methane sensor architecture with new dual gas and dual channel products

FlameIR-ME1 Product Sensor Details



The **FlameIR[®]-ME1** is an ultra-low power NDIR CH₄ sensor using state-of-the-art **solid-state LED optical** technology

The FlameIR[®]-ME1 calibrated for up to 0-5% methane (100% LEL)

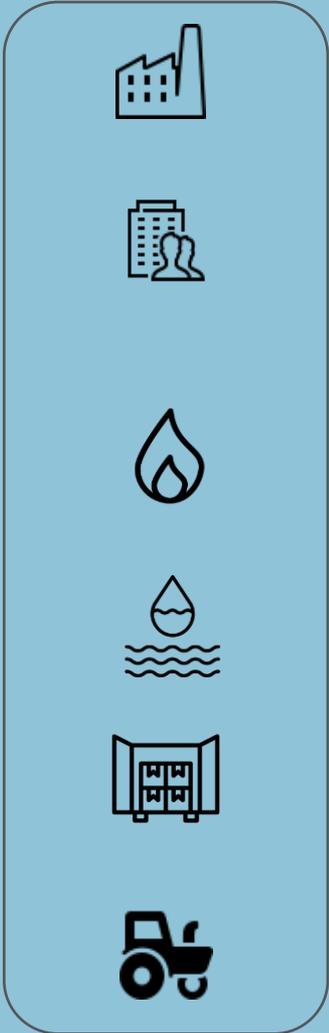
FlameIR[®]-ME1 consumes **~3.6mW average** (or lower at reduced sample periods), making it compatible with mains powered or wearable applications

The FlameIR[®]-ME1 has typically better than **0.01% + 3% of reading accuracy** over the full scale range of the sensor

The FlameIR[®]-ME1 features a **built-in zero-tracking** function to maintain CH₄ measurement accuracy over the lifetime of the product

The FlameIR[®]-ME1 will be certified intrinsically safe to **ATEX II GD Ex ia IIC T4 Gb**

FlameIR-ME1 Target Markets



Industrial safety	<ul style="list-style-type: none"> • Any industry using hydrocarbons as part of a process • Confined space entry safety checks • Mining
Building industry	<ul style="list-style-type: none"> • Brown field site developments often require permanent gas monitoring • Waste dump monitoring • Housing and tower block gas leakage monitors
Gas distribution	<ul style="list-style-type: none"> • Permanent monitoring and personal safety • Confined space leak detection • Wearable safety monitors • Unattended pollution monitors
Water industry	<ul style="list-style-type: none"> • Confined space entry • Waste water treatment works
Shipping	<ul style="list-style-type: none"> • Confined space entry • Cargo monitoring
Environment	<ul style="list-style-type: none"> • Pollution monitors • Agriculture safety • Landfill monitoring

Gases

- Calibrated at the factory for up to 5% (100% LEL) methane
- Can be re-calibrated for other flammable gases (propane, butane, ethane)
 - User programmable multi-point and slope re-calibration possible
- No-need for on-going calibration (only yearly re-zeroing)

Measurement Rate and Responsiveness

- 1.28 seconds per measurement
- Time to first reading ~ 16 seconds (assumes 12 measurements per reading, user programmable)

Environmental Compensations

- Designed to be unaffected by humidity due to special design techniques
- Active real-time temperature compensation
- Ability to adjust reading dependent on ambient pressure levels

Category 1: (aka Zone 0 – FlameIR-ME1)

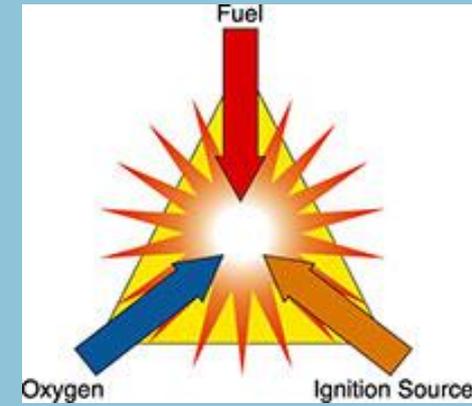
- Equipment intended for high-risk areas where an explosive atmosphere is present long periods.

Category 2: (aka Zone 1)

- Equipment intended for medium-risk areas where an explosive atmosphere may occur under normal operating conditions.

Category 3: (aka Zone 2)

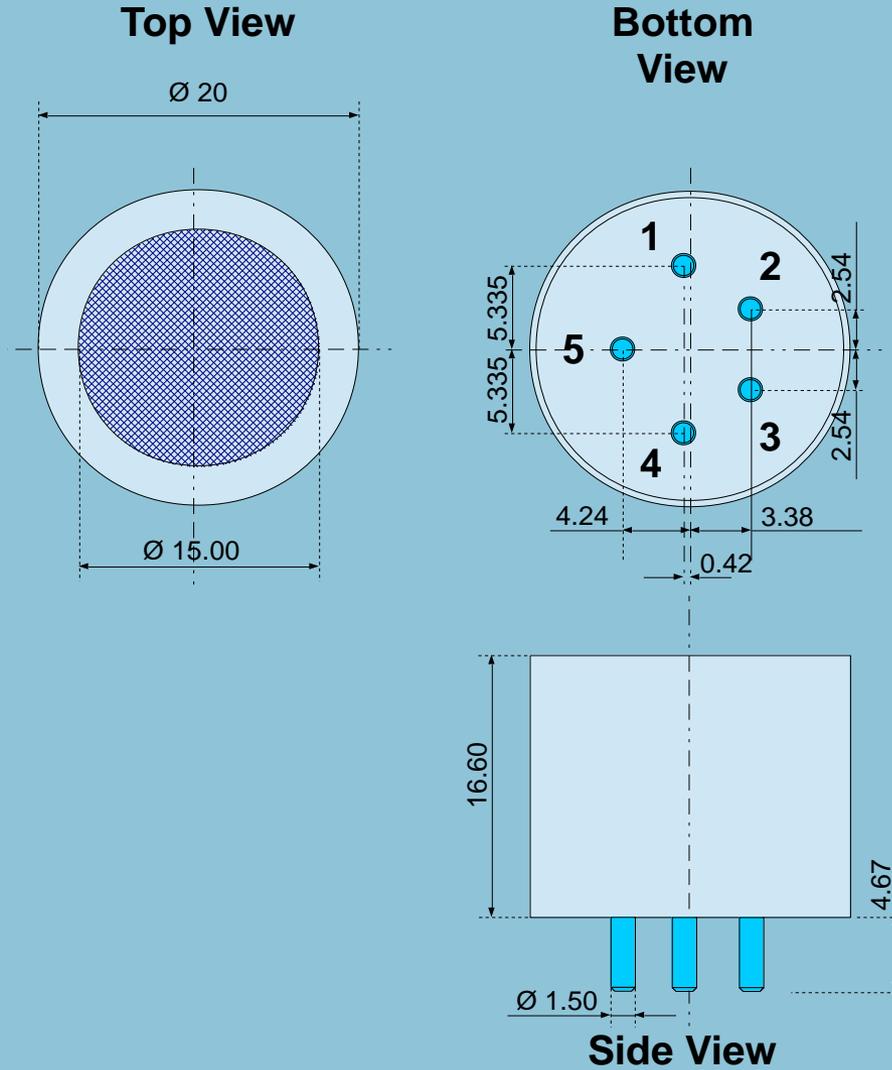
- Equipment intended for areas where an explosive atmosphere is only likely under abnormal circumstances



- Intention is to certify the FlameIR-ME1 sensor to ATEX II 1GD Ex ia IIC T4 Gb

ATEX Only			Ex	ia	IIC	T4	Gb
II	1	GD					
Device Group	Device Category	Surrounding Atmosphere	Explosion Protected	Protection Concept	Equipment Grouping	Temperature Class	Equipment Protection Level
1: Devices to be used in mines II: Devices to be used in areas having explosive gases, liquids or dust	M1: Mines, required to remain functional in the presence of an explosive atmosphere M2: Mines, must be de-energised in the presence of an explosive atmosphere Gas 1: Zone 0 (gas) 2: Zone 1 (gas) 3: Zone 2 (gas)	G: Gas D: Dust		Gas d – Flameproof enclosure e – Increased safety n – Sparking/no-sparking p – Pressurised o – oil immersion q – Powder filled m – Encapsulated i – intrinsic safety	Group I – Mines Group II – Explosive gas other than mines IIA = Propane IIB = ethylene or propane IIC = Hydrogen, ethylene, propane	Gas Temperature class and maximum surface temperature T1 – 450°C T2 – 300°C T3 – 200°C T4 – 135°C T5 – 100°C T6 – 85°C	Ma – Very high level of protection, even when left energised (mines) Mb – High level of protection de-energised (mines) Ga – Very high level (gas) Gb – High level (gas) Gc – Enhanced (gas)
	Dust Zone 20 (dust) Zone 21 (dust) Zone 22 (dust)			Dust m – Encapsulated t - Protection by enclosure pD - Pressurisation	Group III – Explosive dust other than mines IIIA – Combustible dust IIIB – Non-conductive dust (and combustible gas) IIIC – Conductive dust (and for non-conductive and combustible dust)	Dust Maximum surface temperature with tested dust layer	Da – Very high level (dust) Db – High level (dust) Dc – Enhanced (dust)

FlameIR-ME1 Package



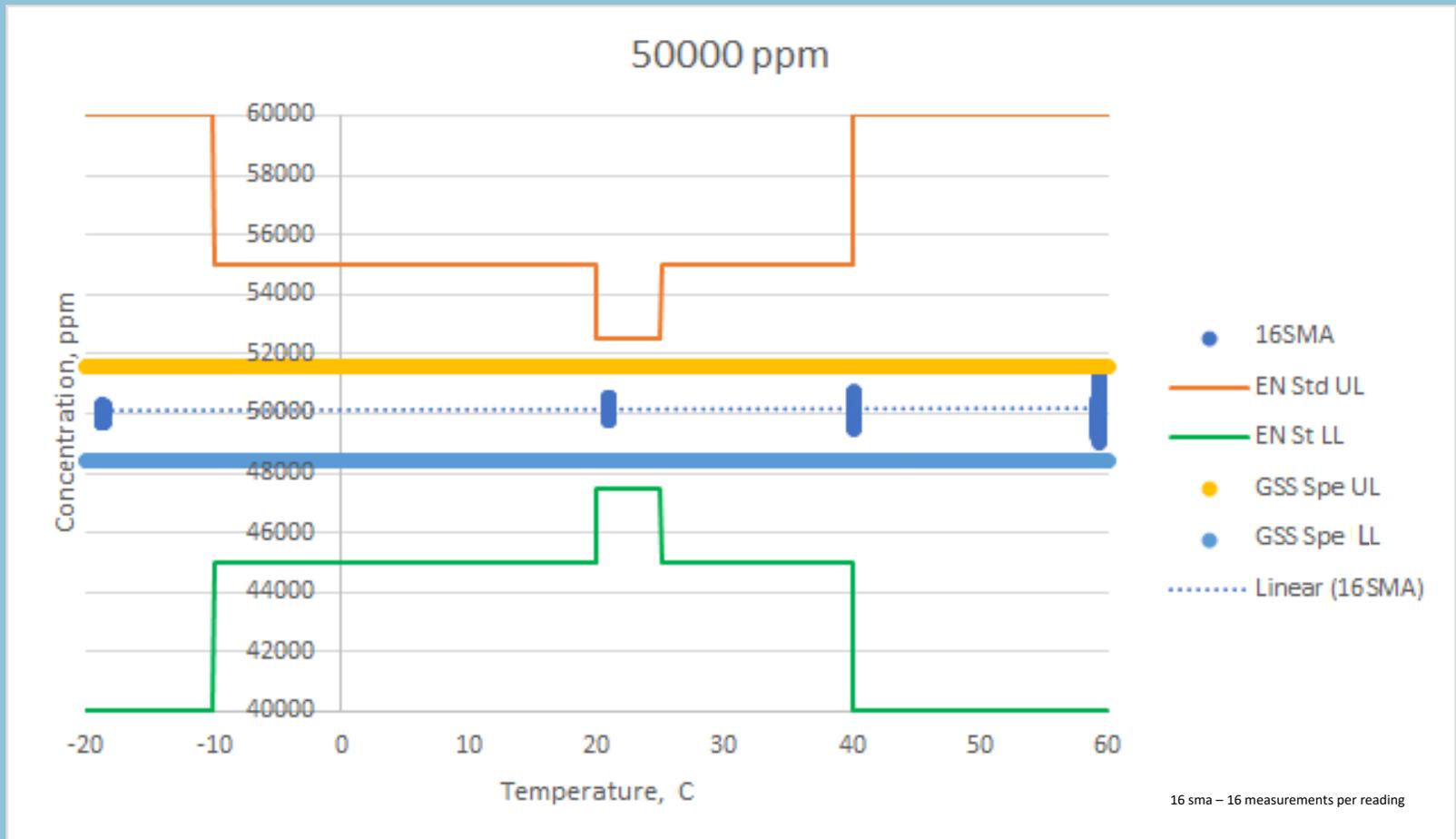
GSS FlameIR-ME1 Parametric Performance*

Gas Sensing Solutions

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
			0		5.0	%vol
Accuracy		@25°C		±(0.01%, +3% of reading)		%vol
Time to First Reading After Power-On		Dependent on filter setting, typ. @ 12 measurements per reading		16		Secs

SETTING	SYMBOL	TEST CONDITIONS	Supply Voltage		Average Power
			V	I (mA)	mW
Sensor Active, measurements @ 1.28 per second		Default settings (un-optimised)	3.3	1.1	3.6

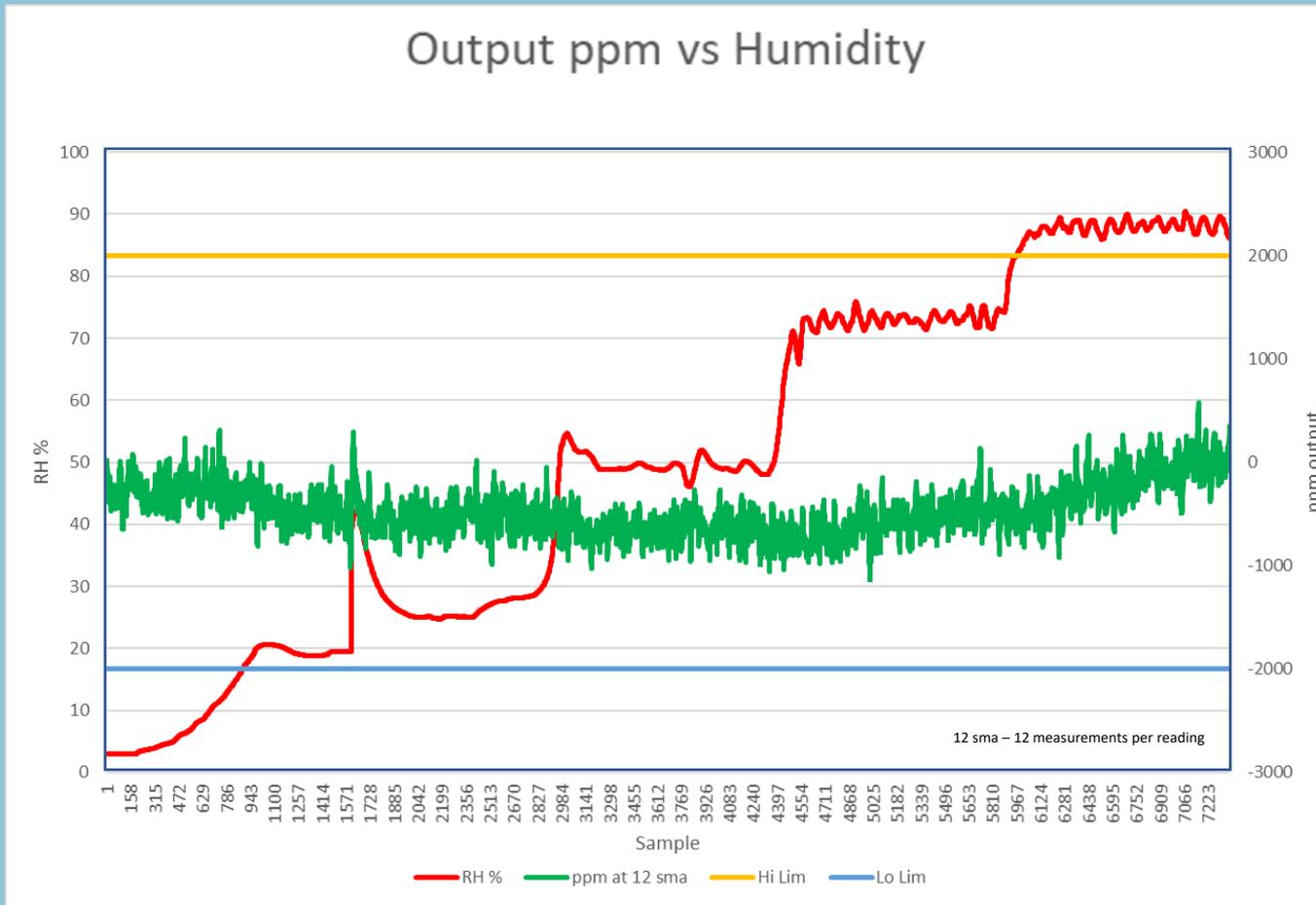
* All parameters actual measured performance



Performance Over Temperature (@ 5% methane)

- Engineering samples stable and accurate over temperature, $<\pm(0.01\% + 3\% \text{ of reading})$
- Well within IEC standard requirements and compares favourably versus competition

FlameIR-ME1 Methane Sensor – RH Performance



Performance Over Relative Humidity (Green Line)

- Engineering samples stable and accurate over humidity, minimal impact on performance due to RH variation
- Well within IEC standard requirements (Hi and Lo limits on graph)

FlameIR-ME1 Features and Benefits

Market Requirements	GSS Product Features	Benefits
Long Battery Life	~3.6mW Sensor Power Consumption @ stated accuracy	Long-term unattended battery powered operation
Measurement Accuracy	±(0.01% + 3% of reading) tested accuracy out-of-the-box experience	Specified and tested accuracy, guaranteed by GSS
Ease of Use	Automatic zeroing with no user intervention	Simple to setup in the field
Multiple Gases	Re-programmable to measure other flammable gases or mixtures	Configurable in the field to measure other flammable gases
Low Maintenance	Low drift performance, reducing need for on-going span calibration	<1 per year calibration schedule for stated accuracy
Robust	Designed for stable and accurate operation, insensitive to shock and vibration	Suitable for portable applications with poor handling
Multiple Interface Modes	UART, I ² C or Analogue Output	Suitable for use in multiple sensor applications

FlameIR-ME1 Methane Gas Sensor Competitive Comparisons



CO2IR[®]

Ultra-Low-Power



SprintIR[®]

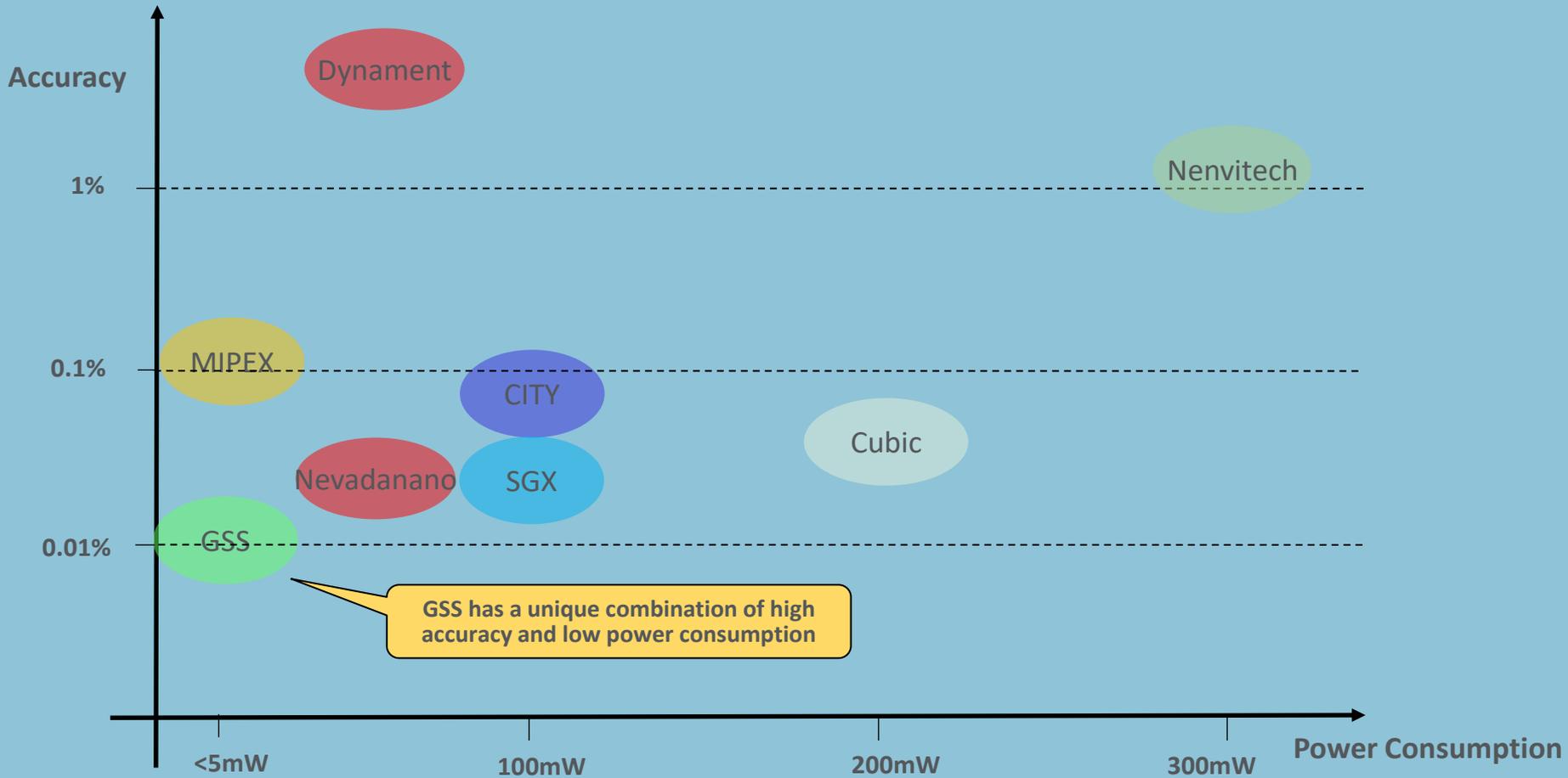
High Speed



ExplorIR[®]

High Reliability

Methane Sensor Power and Accuracy Comparison



Property/Sensor	Accuracy at ambient (%vol)	Temperature range (°C)	Ext temp accuracy	Pressure range (mbar)	Pressure accuracy	Supply voltage Nom (range) V	Power
GSS	±0.01% +3% of rdg)	-20 to +50 or -40 to +60	±(0.015%, +6% of reading)	800 - 1200	tbd	2.97-3.5	~3.6mW @3.3V
SGX INIR-ME	±0.06% or ±6%rdg	-20 to +55	±0.01% < 2% ±0.02% < 4% ±0.05% < 5%	800 - 1200	Not in DS	3.3 (3.2 – 5.25)	115mW @ 3.3V
MIPEX-02-X-X-X.1 X (RX)	±0.1 or ±5%rdg	-40 to +60	±0.4% or ±20%rdg	800 - 1200	±0.2% or ±30%rdg	(3 – 5)	5mW @3.3V
Dynamant MSH2ia	±10% rdg	-20 to +50	±0.1% or ±10%rdg < 50%FS, ±10% rdg > 50%FS or 2%FS if greater	±5% of cal pressure		(3 – 5)	45mW @3V
Cubic NDIR CH4 Sensor SJH	±(0.05% + 5%rdg)	-40 to +70	Not in DS	Not in DS	Not in DS	(3.3 – 6)	200mW @3.3V
Nenvitech IRNET-P	±1%FS < 25%FS ±2%FS < 50%FS ±5%FS > 50%FS	-40 to +60	±3%FS < 50%FS ±5%FS > 50%FS	800 - 1200	0.1 to 0.2% per mbar	(3 – 5.5)	275mW @3.3
Citytech IRcelCH4	±(0.1% + 4%rdg)	-20 to +50	As ambient	700 - 1300	Not in DS	3.3	100mW @3.3V
Nevadanano MPS Methane	±0.025%	Limited, not defined -40 to +75	±0.13%	800 - 1200	Not defined	3.3 – 5.0 ±5%	29mW

Safety Certifications Comparisons

	ATEX	IECEX	UL	SIL	Conditions
GSS	✓ Ex ia IIC T4 Gb	✓			Intrinsically safe due to use of LEDs, no need for flameproof enclosure
SGX INIR-ME	✓ Ex db IIC Gb	✓			1.5W max power thermal resistance Impact Water
MIPEX-02-X-X-X.1 X (RX)	✓ Ex ia IIC Ga	✓	✓ Class 1, Div 1 Group A,B,C,D		
Dynamant MSH2ia	✓ Ex db IIC Gb		✓ Class 1, Div 1		Ui = 6V Pi = 0.8W Ci = 4.105µF Li = 0mH
Cubic NDIR CH4 Sensor SJH		✓ Ex ia IIC T4 Ga			
Nenvitech IRNET-P				✓	
Citytech IRcelCH4	✓ Ex d IIC T4				-20 to +55°C Pmax = 1.4W
Nevadanano MPS Methane					

ATEX (EX)

db = Flameproof enclosure
ia = intrinsic safety

IIC = Explosion Group (almost all gases)

Ga = Equipment protection level Zone 1,2,3

Gb = Equipment protection level Zone 1,2

Max. Surface Temp

T6 = 85deg C

T5 = 100deg C

T4 = 135deg C

T3 = 200deg C

Zone

0 = High risk, always explosive atmosphere

1 = Explosive atmosphere likely to occur

2 = Explosive atmosphere not likely to occur

GSS Methane Sensor Benefits

Market Requirements	Best Competitor	GSS Benefits
Long Battery Life, Small Battery	✓✓	✓✓✓ Lowest Power
Measurement Accuracy	✓✓	✓✓✓ Best Accuracy
Ease of Use	✓	✓✓✓ No In-Use Zeroing Required
Low Maintenance	✓	✓✓✓ Calibration Simple to Use, Yearly
Robust	✓✓✓	✓✓✓ Insensitive to Shock and Vibration
Multiple Interface Modes	✓	✓✓✓ UART, I²C, Analogue Options

Pre-Production Samples

- End Q2 2022

Production Volumes

- End Q3 2022

CO₂ and CH₄ Product Family Summary

Options	CozIR®	ExplorIR®	SprintIR®	FlameIR®
Gas	CO ₂	CO ₂	CO ₂	CH ₄
Measurement Range	Up to 1%	Up to 100%	Up to 100%	Up to 5% (100% LEL)
Accuracy (Typ. @ 25°C)	±(30ppm + 3% RDG)	±(70ppm + 5% RDG)	±(70ppm + 5% RDG)	±(0.01% + 3% of RDG)
Sample Rate	2 per second	2 per second	Up to 50 per second	1.28 per second
Repeatability	±10ppm	±10ppm	±10ppm	-
Temperature Stability	2.5ppm/°C	2.5ppm/°C	2.5ppm/°C	-
Response Time (T ₅₀)	Approx. 30 seconds (diffusion)	Approx. 30 seconds (diffusion)	3.6 seconds @0.1l/min	Approx. 30 seconds (diffusion)
Digital Interface	UART or I ² C	UART	UART	UART or I ² C
Analogue Voltage Output	Yes (Option)	Yes (Option)	No	Yes
Operating Temperature Range	0°C to +50°C or -25°C to +55°C	0°C to +50°C or -25°C to +55°C	0°C to +50°C	-20°C to +50°C or -40°C to +60°C
Operating Voltage	3.25V to 5.5V	3.25V to 5.5V	3.25V to 5.5V	3.3V
Power Consumption (active)	<110uW per reading (Blink)	<3.5mW	<100mW	<3.6mW
Product Options	T and RH (option)	T and RH (option)	None	UART or I ² C, gas type

Sensor Attributes



New Methane Sensor Uses LEDs



LEDs super responsive



Sensor maintains accuracy over temperature and humidity



Ultra-low power consumption



FlameIR-ME1

FlameIR-ME1 Highlights

New methane sensor uses solid-state infrared LEDs to deliver ultra-low power combined with high accuracy (better than 0.01% + 3% of reading)

LEDs turn-on instantly providing initial measurements within ~1.5s, with time to first reading ~16s (12 readings per measurement)

Sensor has been designed to tolerate temperature and humidity variations, maintaining accuracy over a wide range of conditions

Power consumption <5mW with potential to reduce even further under user control, making it suitable for wearable applications

New methane sensor best in class for power consumption and accuracy, available end Q1 2022