

OVERVIEW

NevadaNano's MPS A2L Refrigerant Gas Sensors enable accurate and reliable detection of mildly flammable (A2L) refrigerants common in HVAC applications. Sensor readings are output on a digital bus or configurable analog voltage output. With no field calibration required, the MPS A2L Refrigerant Gas Sensors deliver industry-leading performance and a low cost of ownership. NevadaNano offers three different sensors for three refrigerant gases: R-32, R-454B, and R-454C. Sensors for new refrigerant gases are under development.

The MPS A2L Refrigerant Gas Sensors are available in two form factors: the "Mini" form factor, and the certified "intrinsically safe" (IS) S4 form factor.

GAS DETECTION

| Gas Sensor | Detection Range | Accuracy at 25 %LFL ¹ | Accuracy ≤ 25 %LFL 20 °C, 50 %RH (UL 60335-2-40) |
|------------|-----------------|----------------------------------|---|
| R32 | 5-100 %LFL | ±3 %LFL | ±2.5 %LFL |
| R454B | 9-100 %LFL | ±5 %LFL | ±2.5 %LFL |
| R454C | 8-100 %LFL | ±5 %LFL | ±2.5 %LFL |

¹Accuracy guaranteed across full environmental range. %LFL definition based on ISO817/ASHRAE 34.

PERFORMANCE

| | |
|----------------------------|--------------|
| Resolution | 0.1 %LFL |
| Response time (t_{90}) | < 15 seconds |

ENVIRONMENTAL OPERATING RANGE

| | |
|-------------|---------------------------|
| Temperature | -40 to 75 °C |
| Humidity | 0 to 100 %RH ² |
| Pressure | 80 to 120 kPa |

²Accuracy guaranteed in non-condensing environments. Alternative mechanical configurations can improve condensation robustness.

SELF-DIAGNOSTICS

The MPS A2L Refrigerant Gas Sensor automatically performs a comprehensive sequence of self-checks every 2 seconds to ensure fail-safe operation. The MPS alerts the user of any sensor failure or abnormal status. For additional information on how to interpret and handle detected faults, refer to the MPS A2L Sensor User Manual at www.NevadaNano.com/downloads.

FEATURES

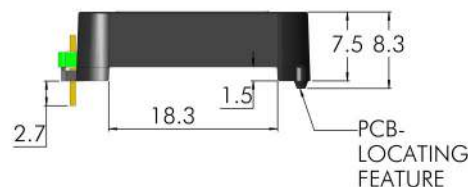
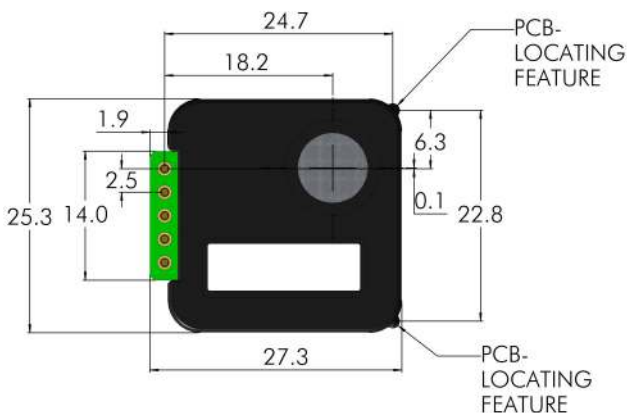
- Built-in environmental compensation
- Extremely poison resistant
- No calibration required
- Supports 15+ year lifetimes
- Low power — 29 mW average
- Built-in self-test for fail-safe operation

OPERATING PRINCIPLE

The Molecular Property Spectrometer (MPS) A2L Refrigerant Gas Sensor's transducer is a micro-machined membrane with an embedded Joule heater and resistance thermometer. The MEMS transducer is mounted on a PCB and packaged inside a rugged enclosure with a screened outlet to ambient air. Presence of a flammable refrigerant gas causes changes in the thermodynamic properties of the air/gas mixture that are measured by the transducer. Sensor data are processed by patented algorithms to report accurate concentration.

MECHANICAL — MINI

Mass 4.3 ± 0.5 grams
 Body material PEI



Dimensions in mm

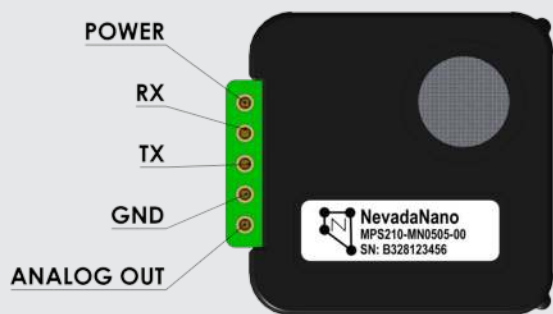
ELECTRICAL — MINI

Operating voltage 3.3 - 5.0 ±5% VDC

Current consumption

Average
8.9 mA

Operating Range
5.0-21.0 mA



Digital Communication: UART
 Logic signaling standard: 3.3 V
 Baud rate: 38,400. 8 data, 1 stop bits. No parity.
 RX Data Input : Do not exceed 3.6 V
 Input High Voltage (V_{IH}) = 2.0 V minimum
 Input Low Voltage (V_{IL}) = 0.85 V maximum
 TX Data Output : Source / Sink 4 mA maximum
 Output High Voltage (V_{OH}) = 2.45 V minimum
 Output Low Voltage (V_{OL}) = 0.45 V maximum
 Programmable Analog out (optional)

Analog voltage output ("Analog Out")

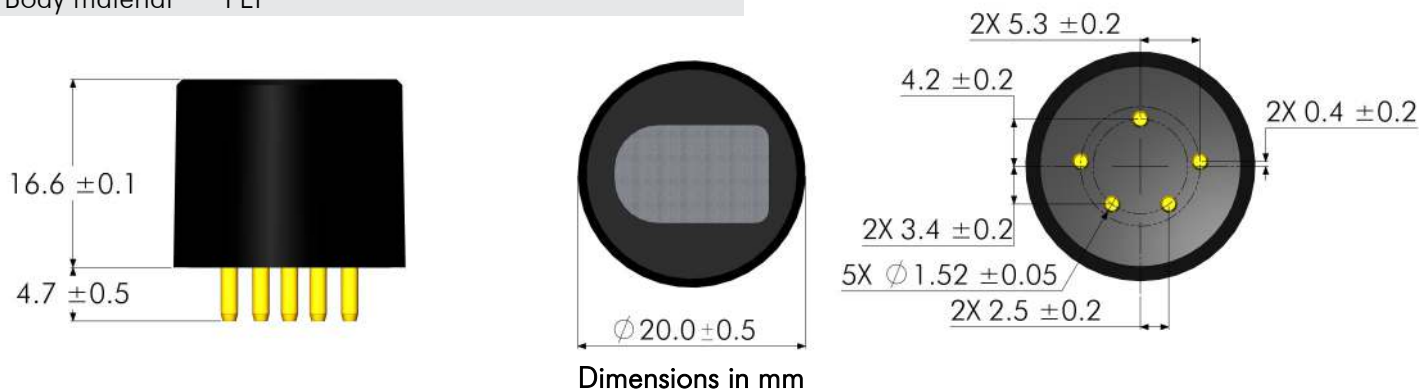
Industry standard 0.4 to 2.0 volt analog output, linearized and compensated for temperature, humidity, and pressure. Alternate configurations available, with output range and "zero" level configurable between 0.04 and 2.9 Volts and configurable sensitivity slope, including rising or falling Volts per %LFL. Contact NevadaNano for details.

MECHANICAL INTEGRATION — MINI

The MPS Mini family of gas sensors is designed to be permanently mounted to a printed circuit board. In addition to the electrical interconnects, the Mini package has two features that can engage with two, unplated 1.10 mm to 1.50 mm dia. holes on the PCB for more precise and secure position of the sensor relative to the PCB.

MECHANICAL — S4

| | |
|---------------|---------------------------|
| Dimensions | 16.6 mm (H) x 20.0 mm (D) |
| Mass | 8.0 ± 0.5 grams |
| Body material | PEI |

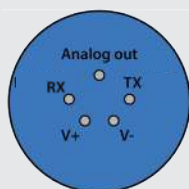


ELECTRICAL — S4

| | |
|-------------------|--------------------|
| Operating voltage | 3.3 - 5.0 ± 5% VDC |
|-------------------|--------------------|

| Current consumption | Average | Operating Range |
|---------------------|---------|-----------------|
| | 8.9 mA | 5.0-21.0 mA |

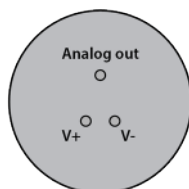
5-pin
Digital Input/Output



Bottom View

Communication: UART
 Logic level: 3.3 V
 Baud rate: 38,400. 8 data, 1 stop bits. No parity.
 RX Data Input : Do not exceed 3.6 V
 Input High Voltage (V_{IH}) = 2.0 V minimum
 Input Low Voltage (V_{IL}) = 0.85 V maximum
 TX Data Output : Source / Sink 4 mA maximum
 Output High Voltage (V_{OH}) = 2.45 V minimum
 Output Low Voltage (V_{OL}) = 0.45 V maximum
 Programmable Analog out (optional)

3-pin Pellistor Replacement
 Programmable Output



Bottom View

Industry standard 0.4 to 2.0 Volt linearized, compensated for temperature, humidity, and pressure.

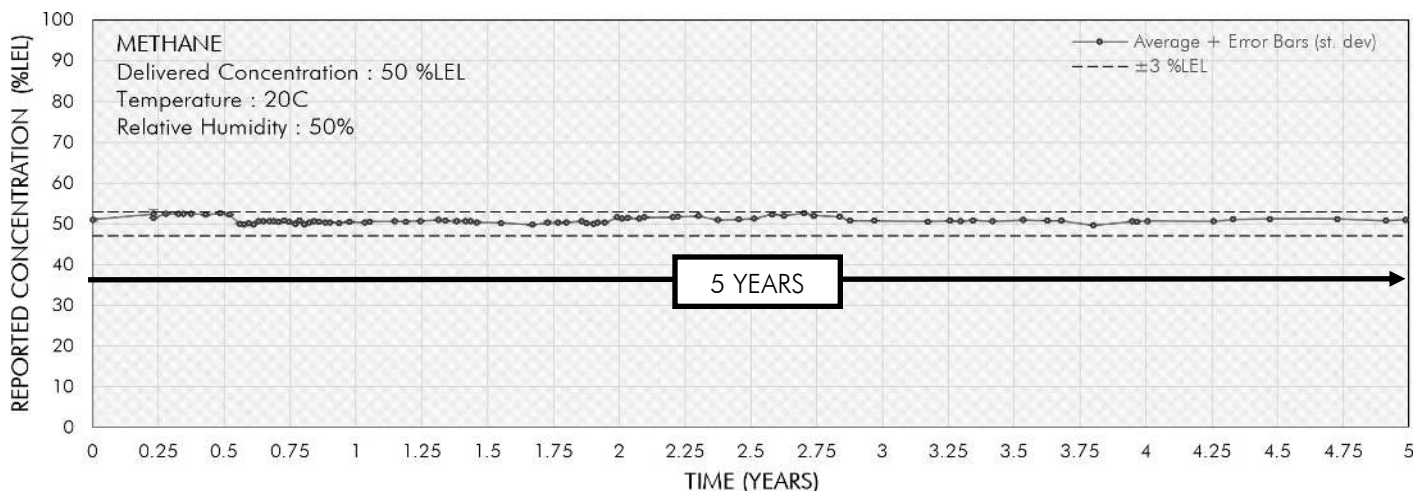
Alternate configurations available, with output range and "zero" configurable between 0.04 and 2.9 Volts and configurable sensitivity slope, including rising or falling Volts per %LFL. Contact NevadaNano for details.

MECHANICAL INTEGRATION — S4

The MPS A2L Refrigerant Gas Sensor in IS form factor is a standard "4 series" size. The sensor interface pins are compatible with industry standard receptacles or socket assemblies.

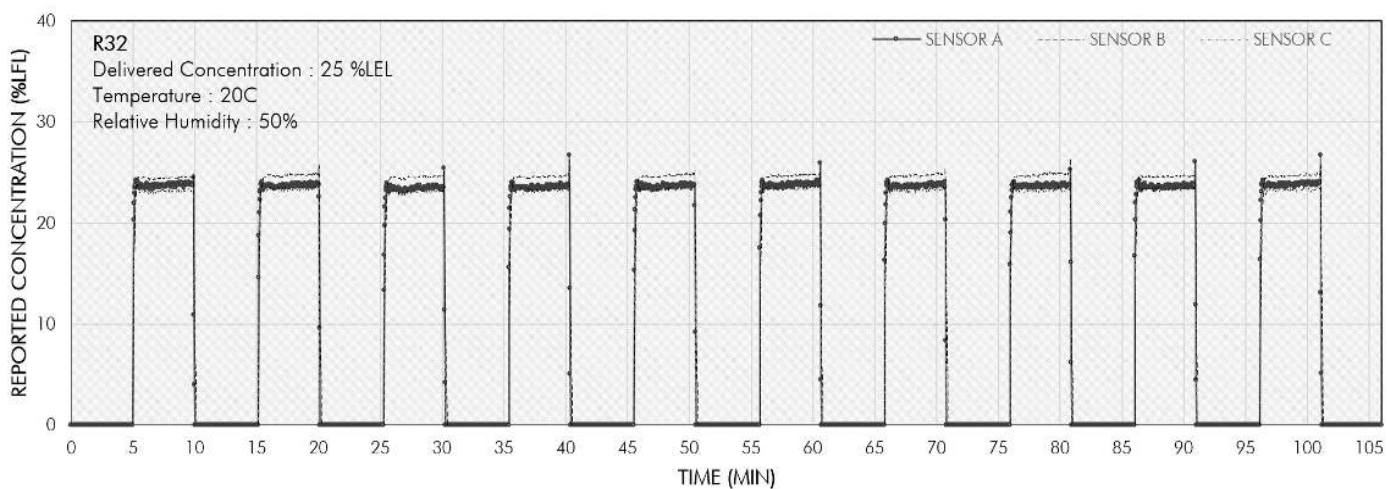
TYPICAL GAS PERFORMANCE CHARACTERISTICS

Long-Term Accuracy/Stability



Average concentration reported by MPS Methane Sensors (utilizing the same MPS technology as the MPS A2L Refrigerant Gas Sensor) to repeated exposures of 50 %LEL methane vs. time. Between exposures, all sensors were operated in ambient air. During exposures, all sensors were placed in an environmental chamber set to standard conditions (20 °C, 50 %RH) and gas was delivered from a cylinder of 50 %LEL Methane. Accuracy has remained within ±3 %LEL over 5 years.

Repeatability



Data plotted from three sensors subjected to 10 exposures of 25 %LFL R-32 over approximately 100 minutes. Standard deviation across all sensors and exposures = 0.13 %LFL.

QUALITY CERTIFICATION

| Certificates of Compliance | Specification | Test Lab/Certification Body | Certificate/Report Number |
|--|---------------|--|---------------------------|
| Certificate of Registration of Quality Management System | ISO 9001:2015 | National Standards Authority of Ireland (NSAI) | 19.8213 |







ADDITIONAL TEST STANDARDS

| Test | Specification | Summary of Test Conditions |
|--|------------------------------|---|
| Low Temperature Operating | IEC 60068-2-1 | 500 Hours @ -50°C |
| High Temperature Operating | IEC 60068-2-2 | 1000 Hours @ 85°C |
| Vibration | IEC 60068-2-6 | 31Hz – 150 Hz (2G acceleration), 1 hour per axis, 3 axes |
| Shock | IEC 60068-2-27 | 50G peak/11ms half sine pulse, 3 axes (positive and negative pulses) |
| Drop | IEC 60068-2-31 | 1-meter drop onto concrete |
| Damp heat - steady state | IEC 60068-2-78 | 500 hours @ 40°C/93% RH |
| Temperature cycling | JESD22-A104E | From -40°C to 85°C for 200 cycles |
| Sand/Dust | MIL-STD-810G Method 510.5 | Sand: 150-850 μm SiO ₂ particle size, 23 m/s nom. velocity, 1.5 hrs @ 70°C per axis, 3 axes Dust: Red China Clay, 1.5 m/s nom. velocity, 6 hrs @ 20°C and 6 hrs @ 70°C |
| Poisoning | NevadaNano | 1,200 ppm-hours H ₂ S (50 ppm for 24 hours) 10,400 ppm-hours siloxanes (Decamethylcyclopentasiloxane) (100 ppm for 4 hours, then 1,000 ppm for 10 hours) 0.25 ppm-hours NO ₂ (3 ppm for 5 minutes) 0.83 ppm-hours HCN (10 ppm for 5 minutes) 0.75 ppm-hours SO ₂ (9 ppm for 5 minutes) 0.17 ppm-hours Cl ₂ (2 ppm for 5 minutes) 4.17 ppm-hours NH ₃ (50 ppm for 5 minutes) |
| Electrostatic Discharge | JEDEC JS001-2017 | Human Body Model, passed at 2 kV |
| EMC: Radiated Emissions | EN 55011 | 30 MHz to 1 GHz |
| EMC: RF Electromagnetic Field Immunity | IEC/EN 61000-4-3 | 80 MHz to 6 GHz at 10 V/m |
| EMC: Magnetic Immunity | IEC/EN 61000-4-8 | 30 A/m, 3 axes, 50 Hz and 60 Hz |

The table above provides a summary of standardized tests and test conditions to which the MPS Flammable Gas Sensor in the S4 form factor has been subjected, and to which the MPS Mini Flammable Gas Sensor is also qualified by assessed similarity. The sensor, which utilizes the same MPS technology as the MPS A2L Refrigerant Gas Sensor, has passed all of these tests by demonstrating performance within the MPS Flammable Gas Sensor specification both before and after each test.

CERTIFICATION — INTRINSICALLY SAFE/S4 FORM FACTOR ONLY

Only the S4 form factor is certified to be intrinsically safe. For additional information on certifications, refer to the MPS Hazardous Locations User Guide here: www.nevadanano.com/downloads

| Certification Body |  |  ATEX NB 2809 |  UKEX AB 1725 |  |
|-----------------------|---|---|---|--|
| Test Standard | IEC 60079-0:2017 IEC 60079-11:2011 | EN 60079-0:2018 EN 60079-11:2012 | | FM 3600:2018 FM 3610:2018 ANSI/UL 913:2019 |
| Protection Categories | Ex ia IIC Ga Ex ia IIIC Da Ta = -40°C to 75°C |  II 1 G Ex ia IIC Ga  II 1 D Ex ia IIIC Da Ta = -40°C to 75°C | | Class I, Division 1, Group A,B,C,D Class II and III, Division 1, Group E,F,G Class I, Zone 0 AEx ia IIC Ga Zone 20 AEx ia IIIC Da Ta = -40°C to 75°C |
| Certificate | IECEx FMG 19.0028U | FM19ATEX0184U FM21UKEX0159U | | FM19US0145U |

| Certificates of Compliance | Specification | Test Lab/Certification Body | Certificate/Report Number |
|-------------------------------------|-----------------------------|-----------------------------|---------------------------|
| IECEx Quality Assessment Report | IEC 80079-34:2018 | FM Approvals LLC | GB/FME/QAR19.0020/00 |
| ATEX Quality Assurance Notification | 2014/34/EU | FM Approvals LLC | FM19ATEXQ0200 |
| UK Quality Assurance Notification | UKSI 2016:1107 (as amended) | FM Approvals LLC | FM21UKQAN0168 |
| RoHS (2 & 3) Compliant | 2011/65/EU & 2015/863 | Underwriters Laboratories | CETR-NNT01.1 |
| China RoHS Compliant | SJT/T 11363 & 11364 | Underwriters Laboratories | CETR-NNT01.1 |
| REACH Compliant | EC 1907/2006 (33 & 67) | Underwriters Laboratories | CETR-NNT01.1 |

The certificates of compliance are available at www.nevadanano.com/downloads

PART NUMBER ORDERING GUIDE

Please refer to the following table when ordering the MPS A2L Refrigerant Gas Sensor or MPS Evaluation Kit.



| MPS MINI FORM FACTOR | |
|-----------------------|---|
| Manufacturer Part No. | Description |
| MPS004-MN0505-00 | MPS A2L Refrigerant Gas Sensor (R32), Mini, 5-Pin, UART + Analog Out |
| MPS210-MN05CC-00 | MPS A2L Refrigerant Gas Sensor (R32), Low Limit of Detection (5000 ppm), Mini, 5-Pin, UART + Analog Out |
| MPS210-MN0509-00 | MPS A2L Refrigerant Gas Sensor (R32), Mini, 5-pin, UART + Analog Out + Auto-Start |
| MPS011-MN0505-00 | MPS A2L Refrigerant Gas Sensor (R454B), Mini, 5-Pin, UART + Analog Out |
| MPS230-MN0505-00 | MPS A2L Refrigerant Gas Sensor (R454C), Mini, 5-Pin, UART + Analog Out |
| MPS230-MN0509-00 | MPS A2L Refrigerant Gas Sensor (R454C), Mini, 5-Pin, UART + Analog Out + Auto-Start |



| MPS S4 (INTRINSICALLY SAFE) FORM FACTOR | |
|---|---|
| Manufacturer Part No. | Description |
| MPS004-S40505-EX | MPS A2L Refrigerant Gas Sensor (R32), S4, 5-Pin, UART + Analog Out |
| MPS210-S40309-E0 | MPS A2L Refrigerant Gas Sensor (R32), S4, 3-Pin, Analog Out, Auto-Start |



| MPS EVALUATION KITS | |
|-----------------------|--|
| Manufacturer Part No. | Description |
| MPS999-S40000-99 | MPS S4 Evaluation Kit (S4 sensor not included) |
| MPS999-MN0000-99 | MPS Mini Evaluation Kit (Mini sensor not included) |