



Sensata
Technologies

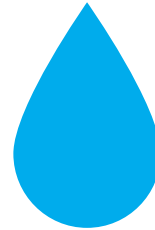
Sensata Resonix A2L Sensors

November 2022

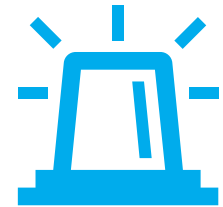
Concerns with Current Technologies



Lifetime and
need for
recalibration



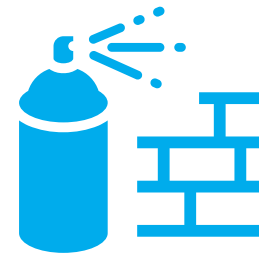
Condensation



False
alarms



High heat
exposure



Risk of sensor
poisoning

The Path to Speed of Sound

1

Initial analysis started in 2018 and included 14 different technologies. We considered both **mass production** and **new technologies**

- MOS
- NDIR
- MOF
- MEMS ultra low power NDIR
- Ultrasonic
- EC electrochemical cell
- Photoacoustic
- Heated diode
- Catalytic combustion
- Thermal Conductivity
- Micro Machine Membrane
- Open source infrared
- Virtual refrigerant charge
- **Speed of sound**



2

Some technologies have been soon dropped for reasons of cost and/or longevity / maintenance needs. Then Sensata did a much deeper analysis on the following 8 technologies and engaged with the possible partners of the sensing element technology

- MOS
- NDIR
- MOF
- MEMS ultra low power NDIR
- Ultrasonic
- Micro Machine Membrane
- Thermal Conductivity
- **Speed of sound**



3

Due to many limitations about the other technologies, Sensata decided to deeply invest on an exclusive technology that can supply all the specs OEMs are asking for.

Speed of sound

Sensata Resonix Gas Sensors

15+ Year lifetime

No calibration or re-zeroing required for the lifetime of the sensor

No False Alarms

No false positives from fouling gases

Built for HVAC

Built to endure the rough environments of HVAC equipment – IP53 and high temp.



Immune to Poisoning

Immune to degradation even with continuous exposure to the refrigerant

Accuracy

Active temperature and humidity compensation for high accuracy over wide ranging environmental conditions

Sensata Resonix Gas Sensors



Fast response time

- Best in-class response time improves system safety

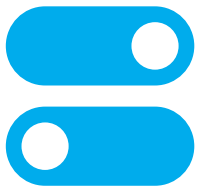
Fast start-up time

- Increased safety in the event of power outages



Low power

- 40mA power consumption



Customizable

- Mitigation Threshold
- Post Event alarm time
- Interface and lead termination
- Available in Modbus, PWM, 4-20mA, and relay outputs



Temperature tolerant
to 105°C while
maintaining sensing

How Speed of Sound Technology Works

It is a technology used to precisely measure the speed of sound in a gas to determine its composition; it is compact, has stable operation over lifetime and does not require recalibration.

Transmit and receive actuators create a standing pressure wave in the cavity. The frequency of this standing wave changes when the speed of sound in the gas changes

The **transmitter** generates oscillatory motion in the gas within the acoustic cavity.

Off the **cavity** resonance frequency the amplitude of this motion is very low.

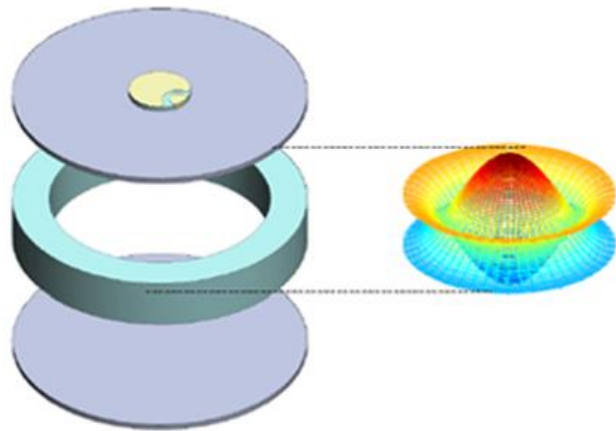
Near the cavity resonance a standing wave is excited and the **receiver** shows a large response.

The speed of sound of the gas (mixture) is calculated from the cavity resonance frequency.

Transmitter

Cavity

Receiver



Physical sensor layout

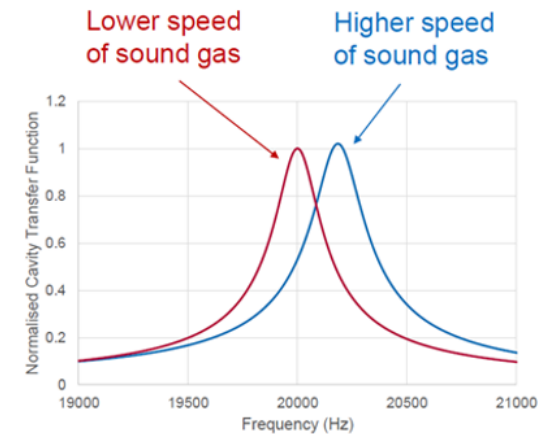
Acoustic resonance excited in cavity

$$f_0 \propto \frac{c}{r}$$

Resonant Frequency f_0

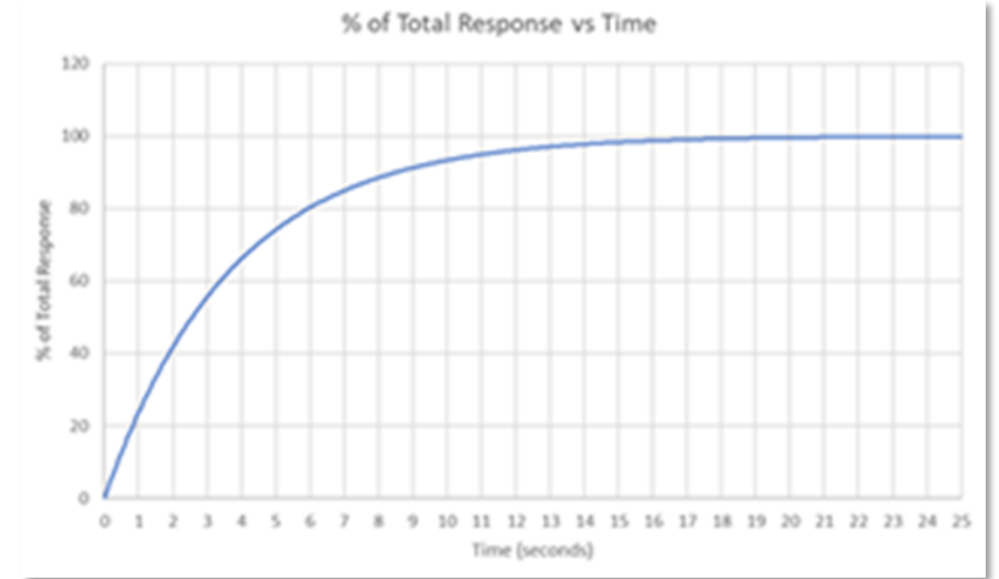
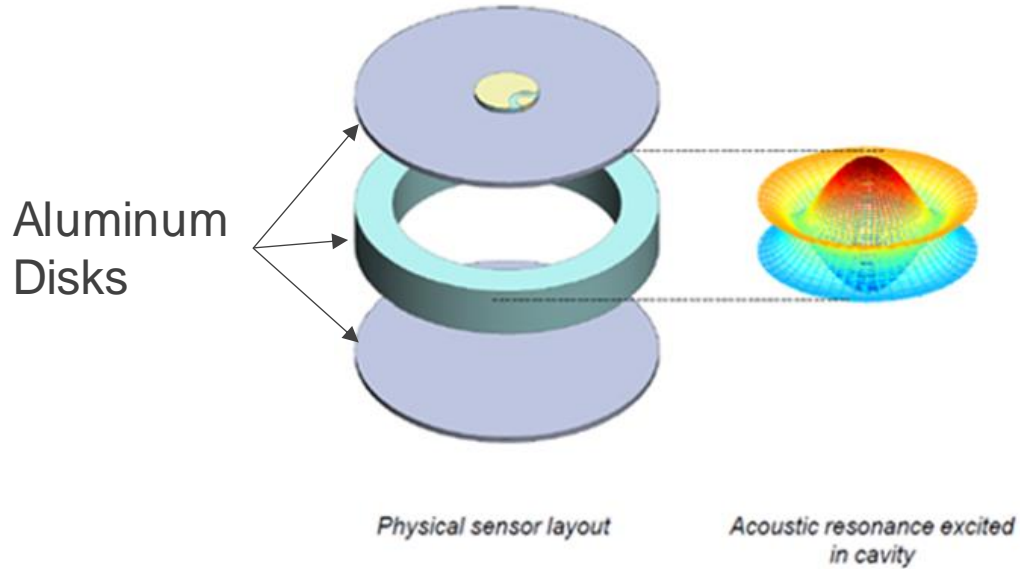
Speed of Sound c

Cavity Radius r



Measurement of acoustic resonant frequency

Greater Peace of Mind with Sensata Resonix™



Robust, solid-state design

- Does not require field calibration or re-zeroing

Long lifetime

- No moving parts
- No chemical reaction
- No degradation in event of continuous refrigerant exposure.

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Sensata Resonix Housing Features

Mounting Features:

- Sized for #10 or #12 Sheet Metal Screw.
- Provide adequate spacing for pneumatic socket drivers.
- Located to facilitate locating sense element lower and in a corner.

Sensor performance independent of rotational mounting orientation.

Housing: PPA GF33

- UL Listed
- UL 94 V0 rated
- UV C tolerant, IEC 60335 1 Annex T

Wire Grommet: EPDM

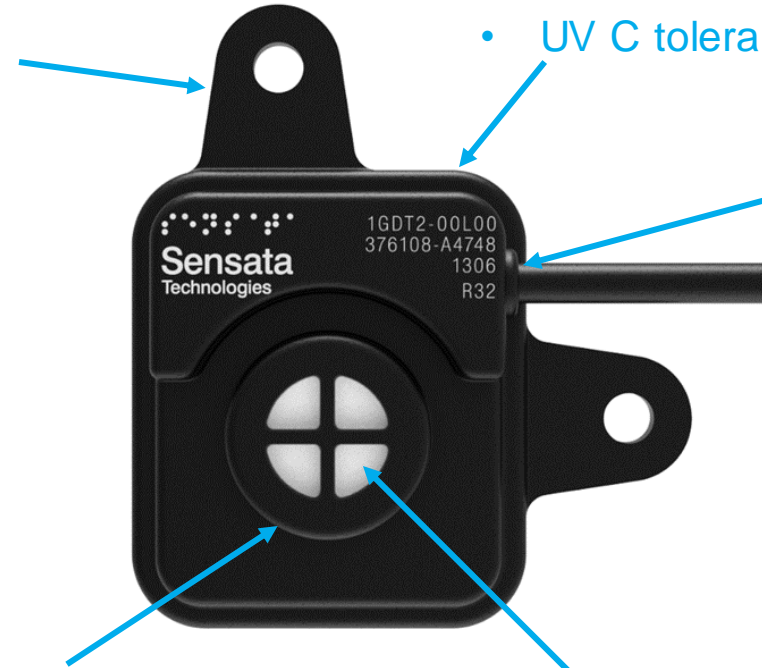
Four Wire, 22 AWG, Input/Output Bundle

- PVC Jacketed PVC insulated wires
- UL 2586 listed
- UL 94 FT2 rated
- UV C tolerant

Sense Element: (not visible)

Picture shown with filter and mechanical features to minimize finger or tool intrusion & achieve IP53

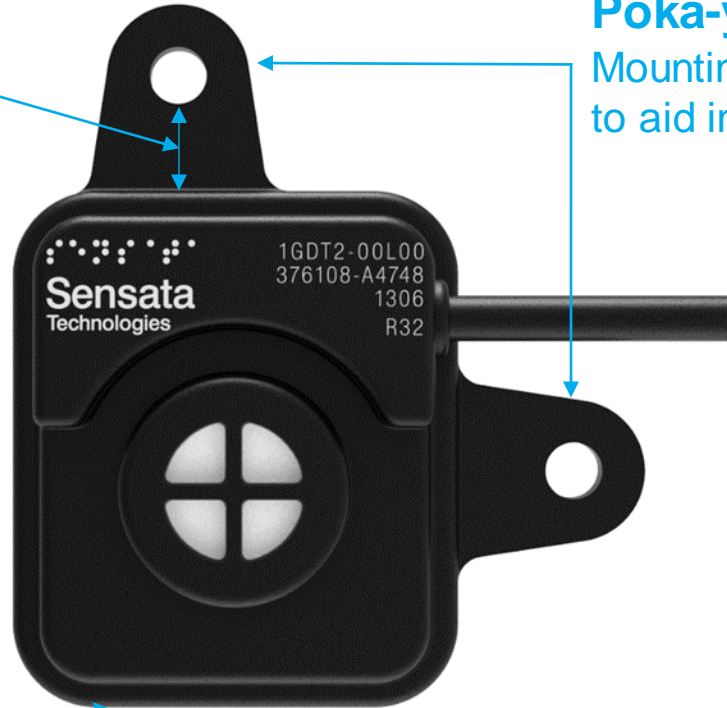
Environmental Seal (not visible):
EPDM Between housing and PCBA around Sense Element to protect electronics from environmental intrusion.



Improved Mounting Features

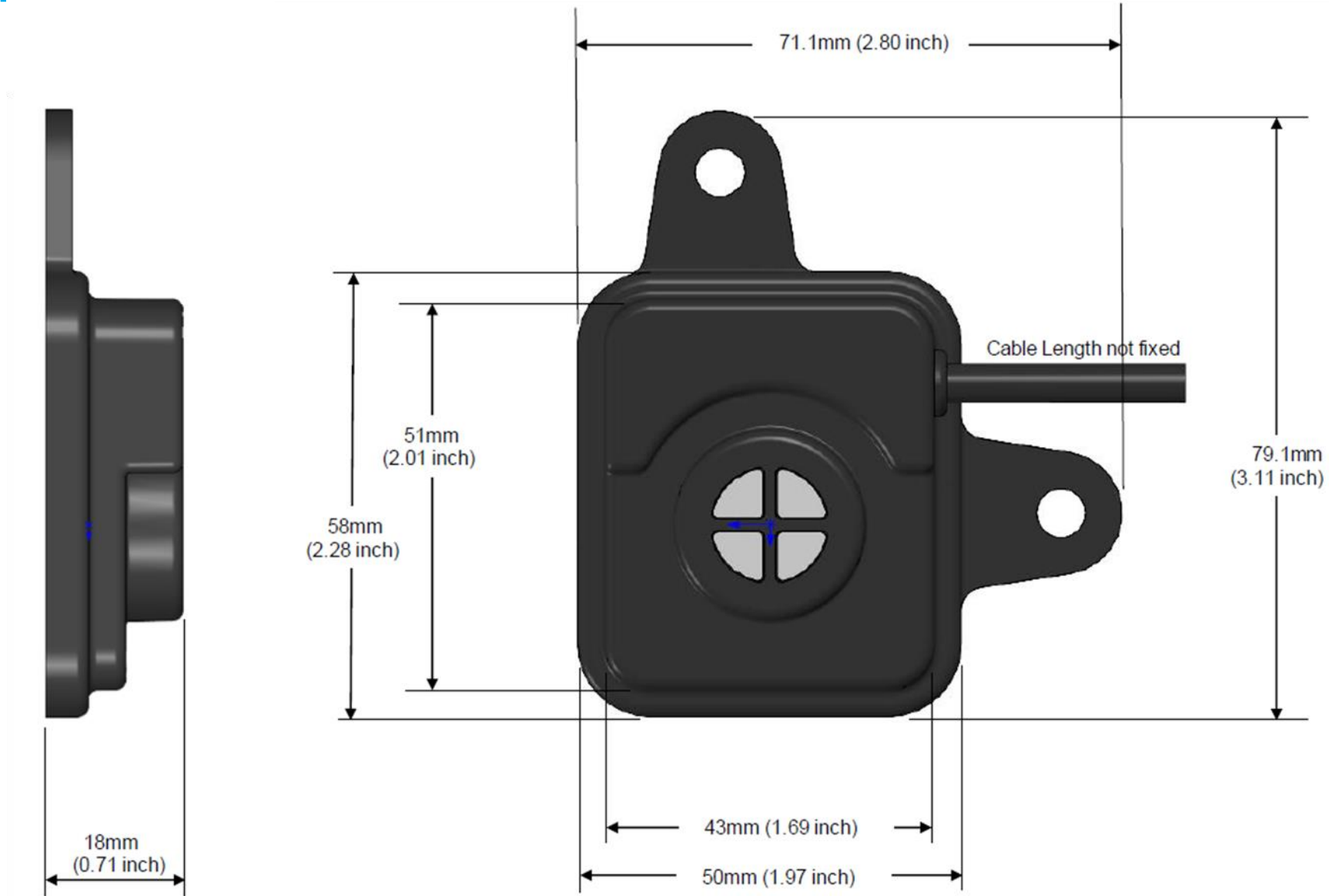
Increased Clearance
For drivers use in assembly to avoid damage to sensor body

Poka-yoke
Mounting tabs placed at 90 degrees to aid in proper sensor alignment



Tab-Free Corner
Allowing for placement of sense element closer to desired location.

Sensor Dimensions



Typical Customer / UL Requirements

Specification	UL 60335-2-40, ed 3	UL 60335-2-40, ed 4
Refrigerant Type	Type Specific	OEM Set able
Response Time	10s @ 100%LFL	30s @ 25%LFL
Accuracy	+/-15% of setpoint	+/-2.5%LFL
Life	No Defined Duration	Demonstrated life greater than Appliance or Limited Life Indicate
Calibration	Not allowed	Not allowed
Self Test	Integrity each 10 sec, OOR each hour	OOR each hour
Warm Up Time	None	None
Set Point	<25%LFL	1 to 25%LFL
Alarm Time	None for Sensor	None for Sensor
Input Power	None	None
Current Draw	None	None
Operating Temp	-20 to 50C	-20 to 50 or appliance specific
Max Intermittent Temp	None	None
Operating Humidity	20 to 50%RH	10%RH@22C & 90%RH@40C
Fouling/False Positive	Limited List @ PPM	Limited List @ PPM
Flammability	V0, 5VA, 5VB (unclear)	V0
UVC Tolerance	None	IEC 60335-1, Annex T

Options Available

Example : RGD-00ML00

