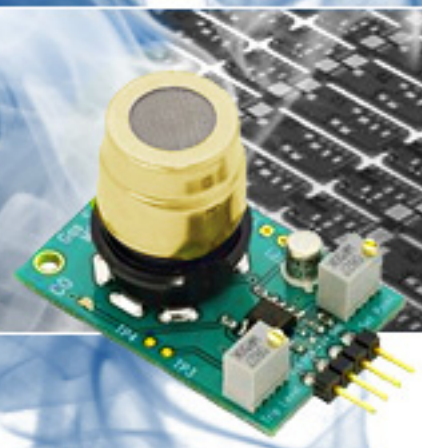
MCQ Gas Blender 100 Series Application

Gas Sensors: calibration, testing and development



Introduction

Monitoring ambient conditions is a fundamental feature providing valuable data for both research and production applications. Any basic or advanced experimentation, any standard or crucial step in a production process demands a fine control over working conditions, thus implying the need of a proper monitoring apparatus. Along with temperature and pressure, the ability to check the atmosphere composition becomes relevant since the presence, absence or simply the amount modification of the gas species can strongly affect the final result. For that reason gas sensors are today a part of the essential equipment of many research labs and production facilities, as well as common safety devices for residential buildings.

Measurement devices like gas sensors require regular maintenance to check and secure proper functioning. Standard procedures usually involve testing and re-calibration of the sensors, for which working atmospheres with specific composition are needed. Creation, control and management of custom gas mixtures can be easily achieved with the new MCQ professional instrument: the Gas Blender 100 Series.

The Gas Blender 100 Series is also an incredible versatile tool for the creation of brand-new gas sensors. The instrument is the optimal choice for developing gas sensors dedicated to applications with specific ambient measurement requirements, for which standard sensors commercially available are not suitable.

MCQ Gas Blender 100 Series

Gas Sensors

There are many types of gas sensor commercially available, built for different purposes and designed for specific applications. Gas sensors can be divided in two main families, electrochemical or spectroscopic, accordingly with their working principle.

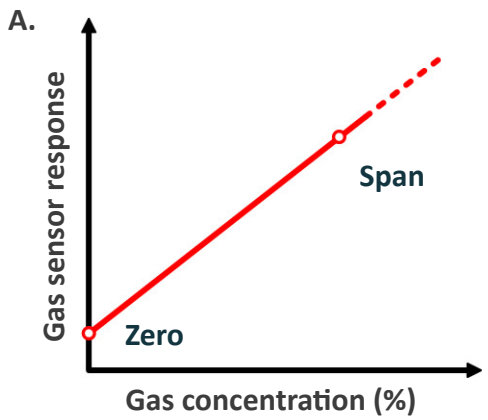
Electrochemical sensor (based on semiconductors property to change their resistivity when in contact with various substances) are commonly used for gas identification and related amount measurement. Spectroscopic sensor (base on the molecules infrared absorption spectra) are generally used for gas traces detection. Gas sensors are precision instruments whose quality and reliability are defined by specific parameters, like sensitivity, accuracy and response time. Some parameters depend on the sensor's nature and remain constant for the whole instrument working lifetime, while others can incur in slight changes potentially affecting the sensor performances (aging). Sensor accuracy is a typical example of parameter naturally affected by the simple sensor usage. A regular maintenance is required to secure the right functioning of the instrument thus a periodic calibration is scheduled during the lifetime of any gas sensor.

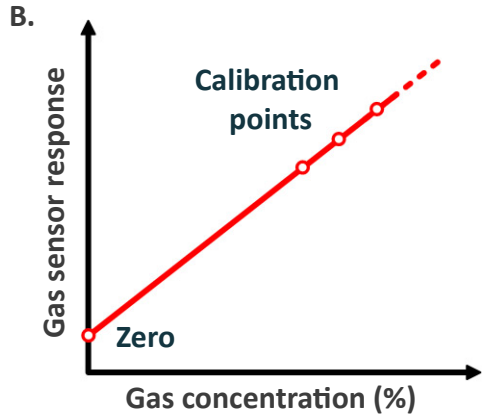
Calibration

The calibration of the majority of commercial gas sensors can be executed by the product supplier or by the user. A calibration performed by the supplier requires a standard fee, to which the shipping cost of the sensor must be added. If the sensor can not be shipped, or requires a specific calibration *in situ*, an operator actually performing the calibration is required and the related cost must be taken into account. A calibration executed by the user does not involve any fee but requires the purchase of a calibration kit appositely created for the management of the sensor.

• Standard method

The standard calibration method involves two steps: setting the "zero" reading (offset) and calibrating the span. The "zero" reading refers to the ideal condition in which the sensor's target molecule is totally absent (e.g. pure nitrogen atmosphere for an oxygen sensor), while the span calibration requires a controlled atmosphere with a fixed rate of sensor's target molecule (e.g. flowing standard air with 20,9% O_2 for an oxygen sensor). Standard calibration kits allows the user to simulate the "zero" reading condition flowing inert gas to the sensor (providing a proper pure gas can) or alternatively setting the reading in vacuum (providing vacuum pump and related equipment). For the span calibration, standard kits also provide a gas can containing a premixed atmosphere to be flown to the sensor. Using premixed atmosphere cans is the fastest and easiest way to perform a





Standard Calibrations:

Examples of standard calibrations for gas sensors with linear response:

A. 2 points calibration. The gas sensors is calibrated setting the "zero" reading and the span. In the best case scenario the "zero" can be calibrated in air while the span requires a can of pre-mixed atmosphere.

B. 4 points calibration. The gas sensors is calibrated setting the "zero" and regulating the slope with 3 different points. This kind of calibration grants a higher accuracy compared with the previous one. In the best case scenario the "zero" can be calibrated in air while the other points require 3 cans with 3 different pre-mixed atmospheres.

standard calibration. This method however suffers two major downsides:

- Accurate calibrations require more than 1 point for the span regulation, thus an expansive set of gas cans, each containing a different atmosphere, is needed.
- Calibration of custom gas sensors may require specific atmospheres not commercially available.

• MCQ solution

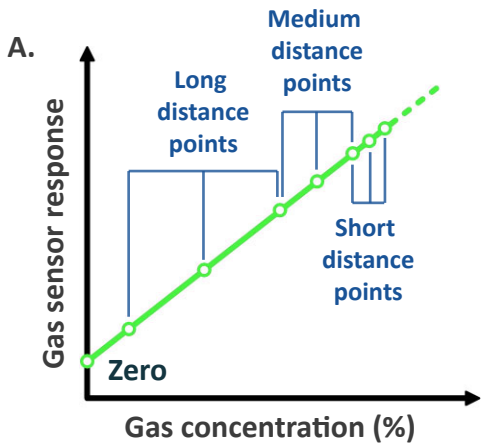
MCQ has developed a new product to overcome these problems: the Gas Blender 100 Series. This product has been specifically designed for applications requiring custom gas sensors. The Gas Blender 100 Series is a professional three channels gas mixer with high precision (1% accuracy for each channel) and high repeatability (0,16% of reading value). The Gas Blender replaces the use of costly premixed gas cans, allowing the user to work with significantly cheaper cans of pure gases which are mixed by the instrument to create custom atmospheres fully adjustable. The possibility to instantly change components concentration in the working atmosphere, with a 0,1%-100% range for each channel, gives Gas Blender great versatility, making it the ideal instrument for standard or advanced calibration of custom and commercially available gas sensors.

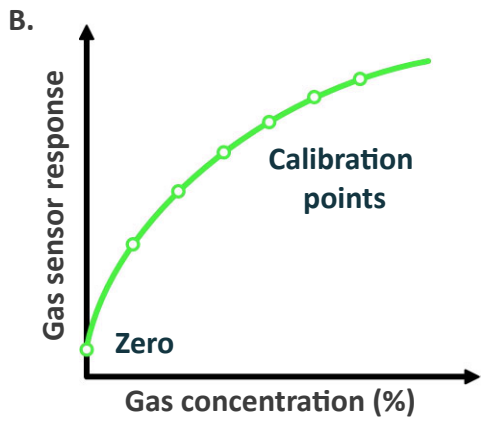
Sensor Development

Development and testing of brand new gas sensors is another important application field for which the Gas Blender 100 Series has been created for. The 3 channels of the gas blender are calibrated by MCQ following the customer request but through standard conversion factors the instrument can be set to work with a wide range of different gasses. Compared with other common Mass Flow Controllers, the MCQ Gas Blender's efficiency allows performing immediate atmosphere composition changes which are fundamental to check the gas sensors response time and other quality-defining parameters.

• Response Time

The sensor response time (RT) is especially important in many applications, since chemical and physical processes, reactions, small changes or variations often occur in a fraction of a second.





Custom Calibration

Examples of calibrations for custom gas sensors:

A. Gas sensors with linear response can be accurately calibrated choosing the desired gas concentrations. The Gas Blender can create custom atmospheres that allow the user to work with long-, medium- and short-distance points calibration curves with extreme precision.

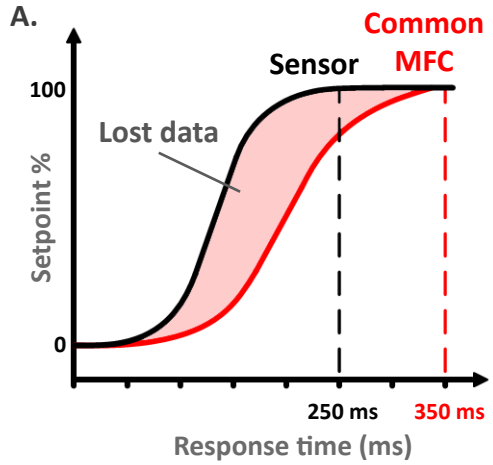
B. The versatility of the Gas Blender is definitely required to evaluate the calibration curves for non-linear response gas sensors. With a minimum distance between 2 points (i.e. the gas concentration) of 0,1% for each channel, the instrument is virtually suitable for any custom calibration demand.

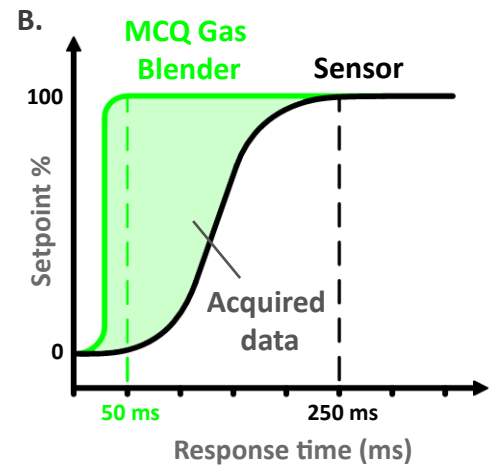
In order to check and verify them, the use of sensors with adequate sensibility and fast RT is mandatory.

Experimental scenario:

- **The working system is surrounded by a specific atmosphere, constantly monitored with one or more gas sensors.**
- **The system, naturally or artificially, incurs in a short-time event that alters the mixture composition for 400 ms.**
- **After 400 ms, the system's conditions are fully restored to thier starting values.**
- **If the sensors' response time is comparable or even higher than 400 ms, the event that caused the variation cannot be detected. The related data are lost.**
- **In order to measure the variation within the system, the sensors' response time must be significanlty lower than the variation's lenght. With a sensor's RT of 100 ms the event's related data can be collected.**

The development of fast response sensors requires in turn an instrument capable of even higher performances. Being able to match and surpass the response speed of the majority of the gas sensors is fundamental to collect valuable data that otherwise would be lost due to poor instrumentation performances. While standard MFCs (Mass Flow Controllers) hardly offer a response time lower than 350 ms, the Gas Blender 100 Series combines its great accuracy with a RT of 50 ms, currently the fastest available on the market. This feature is definitely an excellent tool to verify and improve custom sensor's quality and performance.





Sensor Response Time:

Evaluating sensor's quality for a custom gas sensor with 250 ms of response time:

A. Standard MFCs (Mass Flow Controllers) usually work with a RT of 350 ms or higher. The gap between the 2 speeds makes a proper evaluation of the real sensor quality impossible to achieve. The red area created by the different response times represents potentially valuable data that cannot be acquired.

B. The Gas Blender work with a RT of 50 ms. This speed allows to perfectly evaluate the sensor quality. The green area represents potentially valuable data that can be collected to improve the sensor efficiency.

Compactness and Simplicity

The Gas Blender 100 series combines its high precision and great reliability with two other important features: an extreme compactness, that makes it suitable for any positioning and transport demands, and great simplicity of use.

• Lab in a box

The Gas Blender has been designed with the "Lab in a Box" principle in order to adapt the instrument to any lab needs concerning the working space. MCQ has replaced the standard bulky configuration of 3 Mass Flow Controllers connected with an external power source with a small, practical and easy

manageable product, ideal for installation in narrow spaces or under chemical hoods.

- **User Interface**

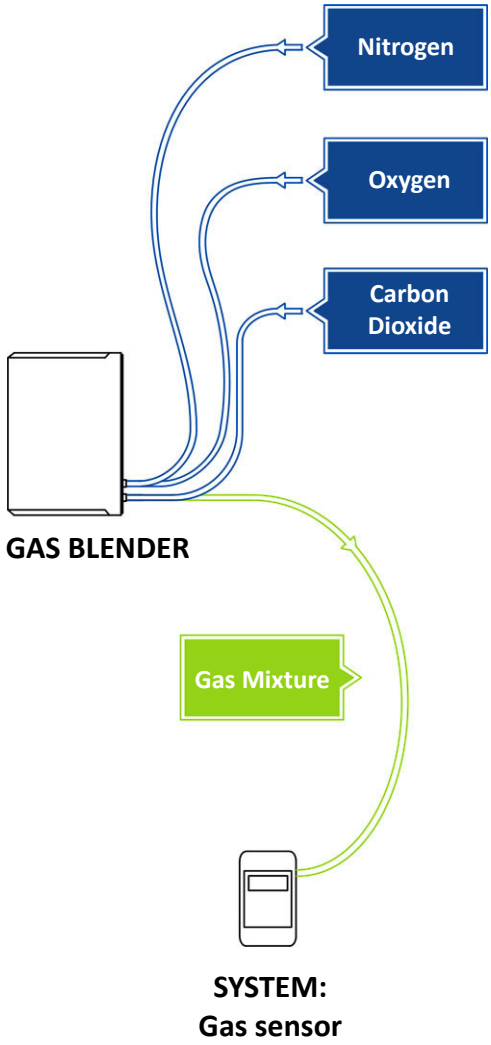
All the Gas Blender parameters and functions can be easily controlled by the user with the MCQ Gas Mixer Manager, provided with the instrument. The software is a fast and intuitive tool for the Gas Blender management and configuration, which only requires a desktop or laptop computer with any Windows operating system starting from Windows XP.

Hardware configuration

The image alongside represents an example of standard hardware configuration required to calibrate a gas sensor with the MCQ Gas Blender 100 Series. The instrument works with dry, non-aggressive gases only. The gas sources can be both pure or mixtures (in our example pure gases have been chosen for simplicity). The gas cylinders are connected to the instrument through 6 mm diameter tubes and a check valve is installed along each line as backflow prevention device. Each gas media is connected and controlled by a dedicated channel of the Gas Blender 100.

Another 6 mm tube connects the instrument to the gas sensor through a specific connector, designed to isolate the sensor from the external environment. For certain applications the zero can be set using the atmosphere that normally surrounds the sensor but for the determination of the other calibration points, the use of the connector is mandatory.

A laptop or desktop computer controls the Gas Blender through a simple USB connection. All the instruments features and the gas mixture properties can then be manage with the Gas Mixer Manager software.



Standard configuration for calibration:

Nitrogen, oxygen and carbon dioxide are blended together to create the appropriate gas mixture for the experiment. The gas mixture flows to the gas sensor detector. For each calibration point, a different mixture is blended.