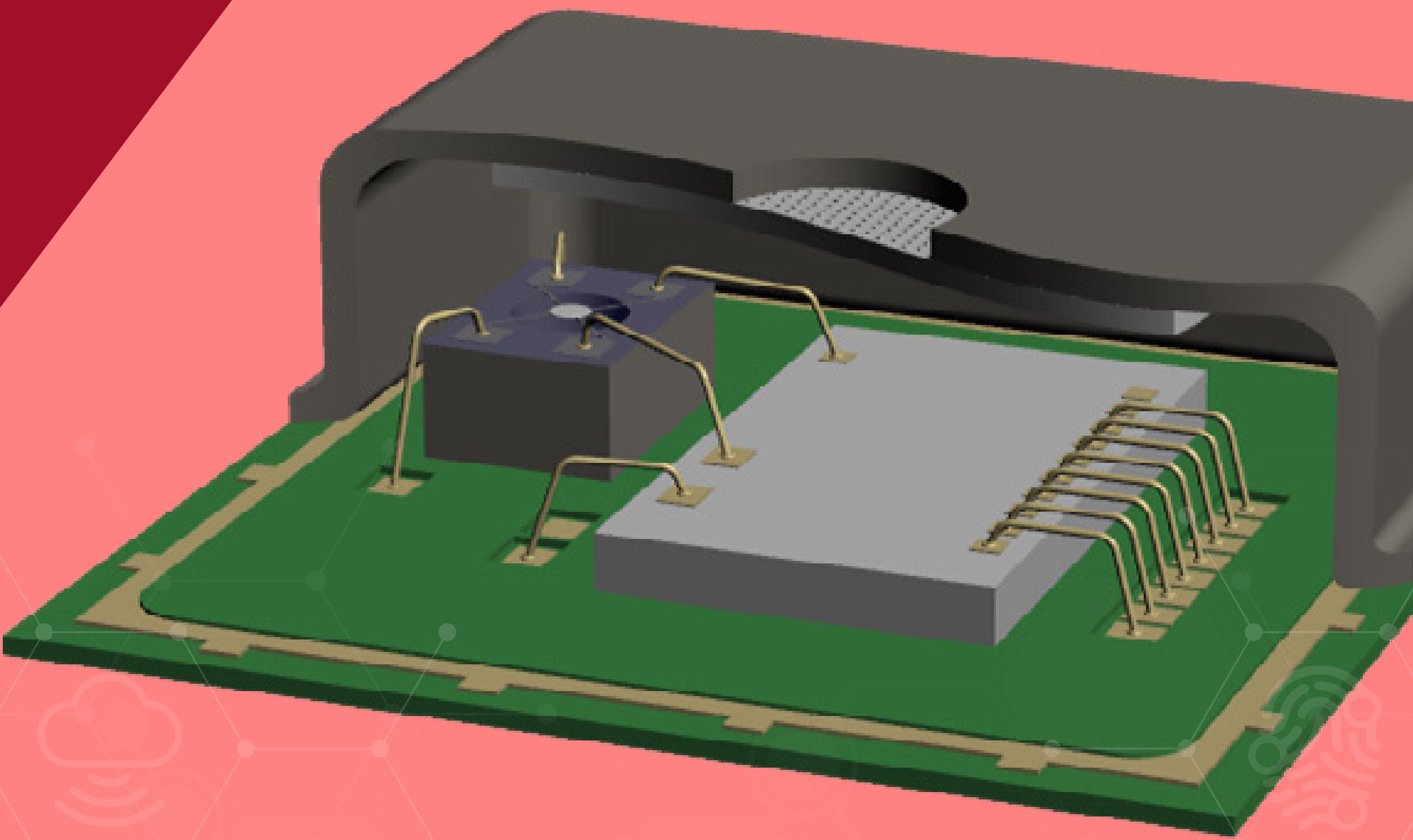

FRESH AIR

Sensors in building automation

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Image: Renesas

Sensors
Connectivity
Security

FRESH AIR
Sensors in building automation

Sensors are the very core of automation in smart buildings. The data they collect provide the basis for all the measures taken in industrial, agricultural, medical and private buildings. Sensors for air quality, lighting and indoor environmental conditions are particular favourites. Distributor RS Components has a versatile range of sensors on offer for this very purpose.

Under Building Automation, the Association of German Engineers (VDI) summarises all measures, systems, processes, tools and services that serve the automatic control and regulation, monitoring, optimisation, operation and management of technical building equipment. These are set out in VDI Regulation VDI 3814, while Regulation VDI 3813 deals specifically with the basics of in-building automation.

In practice, TÜV SÜD divides building automation systems by field level, automation level and management level. At field level, we talk about the operation of a building's technical facilities. The field devices used for this are sensors and actuators.

Fig. 1. Sensors operate at field level

Sensors record current measurement data and feed it into the control loop. The actuators then apply control and regulation algorithms. Typical applications are ventilation, heating, lighting and sun cover. It is crucial that all measures are integrated into one, smart, generic system. This is done either via various wireless solutions or wired bus systems.

In addition to the comfort functions, these systems can create specific environmental conditions. For example, valuable books and documents must be stored at a constant relative humidity of 60% to 65% RH.

If buildings are not sufficiently ventilated, the CO_2 concentration increases. An air quality timestamp is used to specify ventilation intervals, with the CO_2 traffic light system that has been in place since the COVID pandemic.

CO sensors are deemed essential safety devices; this odourless gas is harmful to health and can be fatal. Special conditions also apply to medical premises, greenhouses and special-use warehouses.

An example of 'health research' is the Home4Dem project run by the Lucerne University of Applied Sciences and Arts under the motto, 'Activities of Daily Living', in which presence detectors, pressure sensors and CO2 sensors are used to monitor the behaviour patterns of people living alone. Observed behavioural changes could be an indication of developing dementia or Parkinson's disease.

This sensor technology is also essential in the monitoring of mould formation and reducing greenhouse gases as well as personal safety.

SELECTED SENSOR TYPES FOR BUILDING AUTOMATION

- Gas sensors (CO2, CO)
- Light sensors
- Humidity sensors
- UV sensors
- Light/brightness sensors
- Vibration sensors
- Motion sensors
- Smoke detectors (photodiode)
- Temperature sensors
- Acoustic sensor
- Air pressure sensors

GAS CANARIES

There are many different sensors for gases. Due to current events, including the ongoing pandemic, air quality is currently of particular importance. One of the elements to be monitored in the air inside buildings is carbon dioxide (CO2), which we look at more closely below. This colourless and odourless gas is contained in the ambient air at a concentration of about 400 ppm. Since it is produced as an end product of cellular respiration in humans, its concentration increases the more time people spend indoors. It also depends on the activities being carried out, how well the room is sealed off from the outside air and how long people are in the room for.

The German Committee for Indoor Air Guide Values (AIR) has set out health guidelines for the indoor air concentration of CO2. These guidelines state that a CO2 concentration of below 1000 ppm is considered harmless. Levels of between 1000 and 2000 ppm are cause for concern and require ventilation measures. From a CO2 concentration of 2000 ppm, the indoor air quality is poor and urgent measures must be taken. Smart ventilation systems can be used in this case, which ensure the improvement of the room air while at the same time monitoring energy consumption.

HOW IS IT MEASURED?

Carbon dioxide can be measured using the following methods:

- NDIR sensors (non-dispersive infrared sensors)
- Metal oxide-based sensors
- Photoacoustic sensors

NDIR SENSORS

NDIR sensors are based on the fact that CO2 absorbs infrared radiation in a characteristic way. This is then detected by an IR sensor. For this purpose, we use an IR CO2 sensor with light source, a measuring chamber and an interference filter. The light is not dispersed (non-dispersive). The IR radiation travels from the light source to the sensor, moving through the gas. The filtering only allows the wavelength of the gas to pass through. The concentration of CO2 can be determined from the light intensity. Modern devices also adapt to temperature and air pressure conditions.

The NDIR sensor ExplorIR-W from Gas Sensing Solutions GSS) is a CO2 sensor with an optional analogue voltage output. It is designed for battery-powered systems and performs measurements up to a concentration of 100%. Its response time ranges from 10s to 2 minutes, the operating temperature ranges from 0°C to 50°C as standard or from -25°C to +55°C on the models for extended operating temperatures.

Fig. 2. The GSS sensor measures concentrations of up to 100%. (Image: RS Components)

METAL OXIDE-BASED SENSORS

Metal oxide-based sensors (MOX) use the electrical conductivity of special coatings to detect gases. The resistance of such a coating changes when it comes into contact with a gas. MOX gas sensors react to reducing and oxidising gases and can detect trace gases (CO, NOx, NH3), sulphur-containing gases and hydrocarbons. They can also detect volatile organic compounds (VOCs).

One VOC+NOx sensor used for monitoring indoor air quality is the SGP41 from Sensirion. It has two sensor signals embedded on a chip and uses Sensirion's MOXSens technology. The functions of both sensor signals, which are processed by a gas index algorithm, include enabling air treatment devices to be switched on automatically. There is also an evaluation kit (SEK-SVM4x), which contains the SVM41 sensor module with SGP41 and SHT40 humidity sensor as well as a microcontroller with VOC and NOx index. It reports its data via an I2C or UART interface. In addition to the SVM41, the SEK-SVM4x comes with a UART USB cable, which allows us to the evaluate the sensors, e.g. by integrating them into existing platforms such as Arduino or Raspberry Pi.

Fig. 3. The picture shows the development kit on the left and the SGP41 sensor on the right. (Image: RS Components)

PHOTOACOUSTIC SPECTROSCOPY

Gases can also be detected by photoacoustic spectroscopy (PAS). A gas sample in a measuring cell is irradiated with a pulsed light source (laser) at a special frequency. The gas molecules absorb the light and heat up. This creates acoustic waves that can be detected with transducers (MEMS microphones). The louder they are, the higher the concentration of the gas.

This principle is also used by Infineon's XENSIV PAS CO_2 sensor. A sensitive MEMS microphone is used as a detector. The sensor is suitable for smart home applications and building automation. This includes on-demand ventilation as well as IoT devices such as air purifiers, thermostats, weather stations and personal assistants.

On a PCB, the CO_2 sensor integrates a photoacoustic converter with detector, infrared source and optical filter. The sensor has a microcontroller for signal processing, algorithms and a MOSFET for operating the infrared source. The microcontroller converts the MEMS microphone output signal to a ppm value, which is available via three interfaces: a serial I^2C, UART or PWM interface.

The spectrum for CO_2 measurement ranges from 0 ppm to 10,000 ppm – with an tolerance of ± 30 ppm or ±3% of the measured value. In pulsed mode, the CO_2 sensor is designed for a service life of ten years.

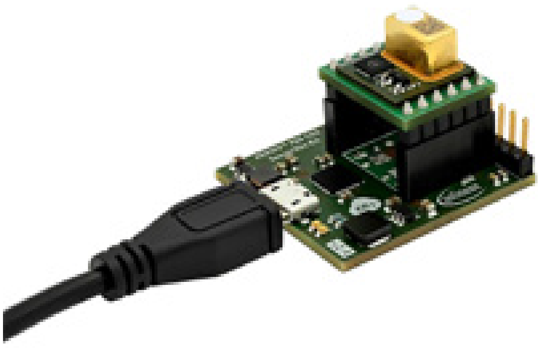

Fig. 4. Here is the compatible evaluation kit. It is called XENSIV™ PAS CO_2 Sensor2Go and can be used in combination with Infineon's PAS CO_2 Mini Evaluation Board (image below). (Image: RS Components)

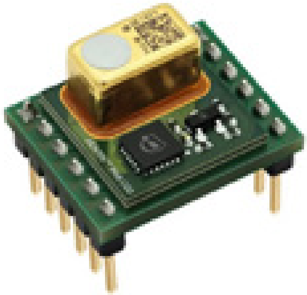

Fig. 5. Infineon's XENSIV PAS CO_2 Mini Evaluation Board enables the experimental setup and design of a CO2 application using a 2.54mm pin header. (Image: RS Components)

The Sensirion SCD40 is another miniature CO2 sensor that uses photoacoustic sensor technology and CMOS technology. This SMD device has dimensions of 10.1mm x 10.1mm x 6.5mm and an output range from 0 ppm to 40,000 ppm. The supply voltage range includes 2.4V to 5.5V. The sensor has a digital I2C interface and also integrates a temperature and humidity sensor.

Fig. 6. Sensirion's SCD40 sensor is as small as a sugar cube. (Image: RS Components)

COMBINING IS ENCOURAGED

Many sensors, modules or development kits combine different functions for collecting environmental data. This allows several parameters to be monitored simultaneously.

An example of this is the 2JCIE-EV01 evaluation board from Omron Electronic Components Europe. It is designed to measure temperature, humidity, air pressure, light intensity, noise and acceleration. A connector allows you to connect add-ons such as the Omron's D6T heat sensor, the D6F-PH MEMS differential pressure sensor, the B5W-LB optosensor and the B5W-LD air quality/dust sensor. The development board can be used with Raspberry Pi, Arduino or Adafruit Feather hosts.

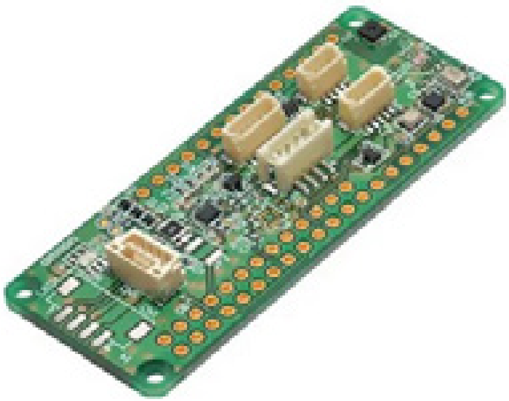

Fig. 7. Omron offers three different variants of the 2JCIE-EV01 sensor evaluation board, depending on whether the prototype is to be hosted on Raspberry Pi, Arduino or Adafruit Feather. The picture shows the Omron Adafruit *3 development kit. It supports six types of sensor functions. (Image: RS Components)

The iAQ-Core from ams Osram is also designed as a compact module and is used to determine the indoor air quality. The integrated MEMS sensor also detects VOCs (volatile organic compounds). The module communicates via the serial I2C bus at 100kHz and requires a power supply of 3.3V. The sensor module implements the air quality sensors with the dimensions 15.2mm x 17.8mm x 4.3mm.

Fig. 8. The module is available in two variants – for continuous operation or for pulse operation. (Image: RS Components)

A complete system for air quality monitoring in the room is the CLIMA DemoPack from Electronic Assembly/Display Vision. It consists of a 2.8” IPS display including PCAP (Projective Capacitive Touch) and an application board with environmental sensors that measure temperature, humidity and CO2 gas. The miniature touchpanel can be used as a replacement for physical switches and controllers in home automation. There is also a TFT panel, cables, connectors and accessories as well as the WYSIWYG graphics tool uniTFTDesigner for creating screen layouts, user interfaces and functions. Using drag-and-drop, you can integrate touch fields, texts and images into screen pages and change object properties. A simulator, macro editor and debugger are also included so you can develop projects without hardware.

Fig. 9. The kit is suitable as a development platform for applications in the smart home sector and in the industrial environment. (Image: RS Components)

The CO_2 sensor development kit T6713 from Amphenol Advanced Sensors is designed for microprocessor devices. Under the Telaire brand, Amphenol Advanced Sensors offers CO_2 sensor technology, air quality sensors for measuring dust according to the particulate matter (PM) 2.5 and PM 10 particulate matter standards, and relative humidity (RH) solutions. The T3022 series was specially developed to record CO_2 levels. The sensors are IP65-protected, use non-dispersive infrared (NDIR) measurement technology and allow installation with a 5V input and an I2C digital output.

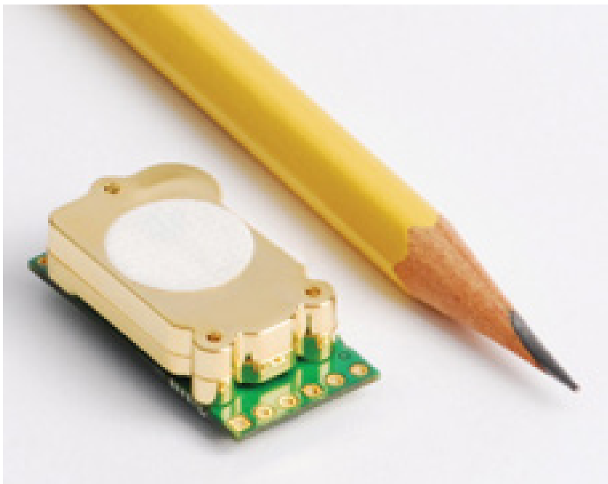

Fig. 10. The Telaire CO2 series sensor module is designed for applications where indoor air quality CO2 levels and energy-saving applications such as on-demand ventilation need to be measured and controlled. All units are factory calibrated to measure CO2 concentration values up to 5000 ppm. (Image: RS Components)

The enviro:bit kit from Pimoroni (PIM355) is equipped with sensors for air and weather, colour and light as well as sound, and can be plugged directly into a Micro:bit board. The Micro:bit is a single-board computer developed by the BBC in 2015, which is used by educational organisations worldwide for learning programmes in science, technology, engineering and mathematics (STEM), among others. The kit includes a MEMS microphone and offers Microsoft MakeCode and MicroPython support.

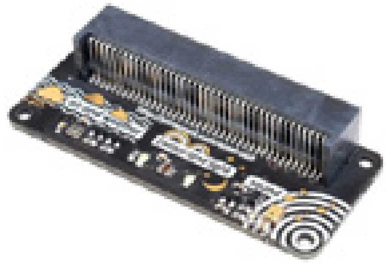

Fig. 11. The PIM355 is simply plugged onto a Micro:bit – no soldering required. (Image: RS Components)

The ZMOD4410 EVK) evaluation kit can be used to evaluate Renesas' ZMOD4410 gas sensor module for indoor air quality. It measures volatile organic compounds (TVOC) as an indicator of indoor air quality. It also comes with measurement modes to trigger an external device (e.g. fan, ventilation) based on a change in air quality, and to distinguish sulphur odours. The kit includes the Hicom communication board, the sensor board with the ZMOD4410 gas sensor module and a 0.5m-long USB to Micro USB Type B cable.

Fig. 12. The kit works with Renesas software – either with an executable ZMOD4410 GUI or alternatively with firmware programming. It allows you to connect sensor boards for different gas sensor models and integrate with other sensors via the I2C interface. (Image: RS Components)

The BME688 MEMS sensor from Bosch Sensortec can be used to simultaneously measure gas, humidity, temperature and air pressure. AI functions of the sensor and the software tool BME AI-Studio help with the development. There is also an Adafruit-compatible development kit.

The BME688 is based on the BME680 platform from Bosch Sensortec. The gas sensor is capable of detecting a variety of gases, including volatile organic compounds (VOCs), volatile sulphur compounds (VSCs), and carbon monoxide. It can also be optimised for other gas mixtures and applications with a specific software.

In addition to gases, the BME688 measures humidity, air pressure and temperature and uses this additional data to create an AI model.

The housing of the sensor has the dimensions 3.0mm x 3.0mm x 0.9mm. The power requirement can be configured at 2.1µA to 11mA depending on the required data rates and functions, and optimised with the BME AI studio.

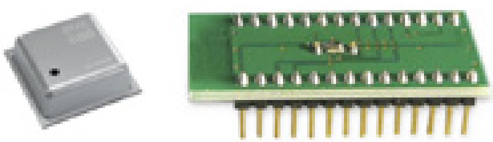

Fig. 13. On the left you can see the BME688 sensor, on the right its evaluation board. (Image: RS Components)

In addition to the sensors and development kits mentioned above, RS Components offers other products from the field of sensors for building automation.