Understanding the Limitations of Low Power NDIR Gas Sensors

When it comes to sensing our environment, it is of great interest to minimize power consumption. Not only does the production of energy affect our climate negatively, reducing power consumption also creates opportunities in new markets.

In times when air quality is becoming one of our largest global issues, interpreting what we measure is more relevant than ever. This helps us to make better choices both for our earth and our own health and safety. Lowering the energy consumption of sensors does not only have impact on the economic aspect of energy saving, it also creates new market opportunities that radically can improve our decision making. Most important is the measurement of CO_2 concentration in air. The SensAir S8 LP is a battery powered non-dispersive infrared absorption sensor module. As more and more things start to talk to each other, the progress of IoT has increased a lot in recent years. As collecting data in cloud based solutions has become more popular, the market has recognized the advantage of having more measurement points. With this, the need for battery powered solutions is an increasingly important demand of customers. A battery powered device creates a multitude of opportunities. The sensor battery can be recharged by energy harvesting of ambient energy; may it be solar, thermal, wind or any other green energy source. This means we can now multiply our measurement points without further impact on our environment and sensors can be placed at sites where there is no fixed power supply. Our battery powered measurement system requires only 3.6 mC per measurement cycle, equal to an energy of 11.9 mJoule at 3.3 V battery supply voltage. The measurement period can be adjusted to the customers need.

▲ **The entire development and production is placed in Sweden.**

But does this come at a cost?

It might. There is a fundamental relationship between invested power and measurement resolution in all electronic sensors – the more electrical energy you invest in the measurement, the more accurate reading you will get. Therefore, obtaining high resolution measurements using a low power sensor is a challenge. The accuracy of a

▲ **Every single sensor goes through a variety quality examinations.**

sensor reading is limited by systematic and random errors. The systematic errors are determined by the stability of the optics, the quality of calibration, systematic errors in the electronics and the quality of the algorithms used. These errors are not related to electrical power. Instead it is the quality of the material in the sensor and the skill of the sensor manufacturer. On the other hand, the random error is directly linked to the power we put into the sensor.

The correlation between power and resolution can be easily understood. The nature of this error, called electrical noise, is random. Every time you make a measurement the detection electronics »rolls a dice« and adds a random number to the measurement. We could use two sensors and use the average as the measurement value in order to reduce the random error. This will work but you have to double the power since two sensors must be powered. Another way to obtain the same result without the additional hardware is to turn on the infrared light source of the sensor and make measurements twice as often. You can now improve resolution, or reduce the noise, by taking the average of two measurements. But still, powering up the light source twice as often doubles the power used for light generation. From statistical arguments you can find that

▲ **SensAir S8 LP**

the resolution is proportional to the square root of invested power when you vary the duty cycle of the measurement. Hence, when reducing the power the resolution will get worse proportional to the square root of the power. This means that if we want to reduce power consumption 100 times the resolution will 10 times worse. At usual conditions the S8 average current can be 18 mA at a measurement interval of 4 seconds, this can be reduced to 61 µA at a 60 second measurement period, or to 31 µA at a 120 sec measurement period.

Another way to trade power and resolution is by the signal strength. Since the noise is generated by the detection electronics we can gain resolution by increasing signal strength. Let us say that if we double the light flux from the light source we will get twice as much signal with the same noise. This will result in twice the resolution. In this case the resolution is linearly proportional to the output power from the light source. If light power is reduced 100 times the resolution will also be reduced 100 times. When optimizing for low power, the skilled sensor designer will first choose low noise components for detection electronics and optimize the optical design for maximized signal. After that the light, source power and measurement duty cycle must be traded to fulfill the requirements of the resolution, battery life and measurement period. From the discussion above it is found that the overall power consumption is minimized by increasing light flux and reducing duty cycle. Imagine that you increase the light power 10 times. This will increase power consumption 10 times and improve resolution 10 times. Now we can allow for 100 times reduction of duty cycle that will reduce resolution 10 times. At the end, the resolution will be maintained while power consumption is reduced 10 times. The high output power, or light flux, of traditional incandescent lamps explains why they are still considered better than light emitting diodes in low power applications.

So to maximize the outcome of this new market opportunity by reducing the environmental impact and at the same time from an economic perspective save the most money, there are three things you need to consider: The power consumption, the accuracy of the reading and the life span of your sensor. Our sensor has a life time expectancy of more than 15 years. Make sure you go with a supplier who understands all three of these criteria.

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