NDIR: Running the IRC-A1 at reduced lamp voltages

The unique optical design of the Alphasense IRC-A1 NDIR sensor leads to a high-level of incident photons at the detector and subsequently very high signal levels.

This has obvious advantages such as increased signal-to-noise ratio, less need for amplification of the signal and consequently less complex signal processing electronics.

However, there are also less obvious benefits of such a high level of incident radiation, which can be realised by decreasing the lamp drive voltage.

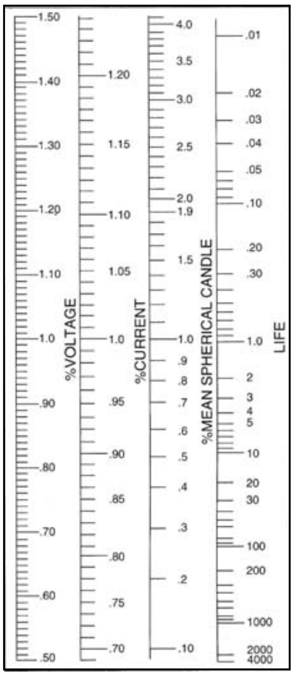
Typically, 20-mm diameter NDIR sensors (including the Alphasense IRC-A1) are fitted with lamps designed to run at 5 V.

Reducing this lamp voltage leads to a decrease in the light output and sensor performance.

However, the inherently large signal generated through the good optical design of the IRC-A1 means the Alphasense sensor can be driven at lower voltages, while still maintaining a good signal-to-noise ratio.

This reduction in lamp driving voltage has three major benefits:

Increased lamp lifetime:
Decreasing the lamp voltage increases bulb lifetime significantly.
If the voltage supplied to the lamp is 50 % of the design voltage, the lifetime of the bulb can be up to 4000 times longer (see right, taken from Gilway Technical Lamp Engineering Catalogue 169).



Significantly reduced power consumption:

If the lamp voltage is decreased, the current is also decreased, such that if the lamp voltage is halved, the power is more than 50 % less (see right and Table 1).

Lamp Drive/V	Lamp Current/mA	Average Power (50% duty cycle)/mW	Normalised Detector Output
5	60	150	1.00
4	55	109	0.76
3	47	70	0.51
2	38	38	0.26

Table 1: Lamp current, average power and normalised detector output as a function of lamp voltage for an Alphasense IRC-A1 NDIR sensor.

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Shorter warm-up times:
One of the disadvantages of all NDIR sensors is that the sensor needs a significant time to warm up to operating temperature following lamp switch-on due to the heat generated by the lamp warming up the entire sensor.

This can be minimised by reducing the lamp voltage and subsequent self-heating of the sensor.

Figures 1 (a) and (b) show the internal temperature of eight IRC-A1 sensors over a time period of 60 minutes following switch-on with lamp driving voltages of 5 V and 2 V respectively.

At 5 V the temperature rises by 4 to 5°C, whereas at 2 V the increase is much less, around 1 to 2°C.
The lower temperature increase at 2 V leads to faster stabilisation of the internal temperature of the sensor.

This reduces the time necessary to establish a stable signal.

This can be seen in Figures 1 (c) and (d), which show the absorbance in Nitrogen for the same eight sensors during the warm-up period for 5V and 2V lamp voltages respectively.

Note that these sensors were fitted with a large gassing hood and so the thermal equilibration is significantly slowed and the warm-up time is longer than would be expected for an open sensor.

Nevertheless the faster equilibration at 2 V is clear.

However, Figures 1 (c) and (d) make clear the disadvantage of running the sensors at a lower drive voltage: increased noise.

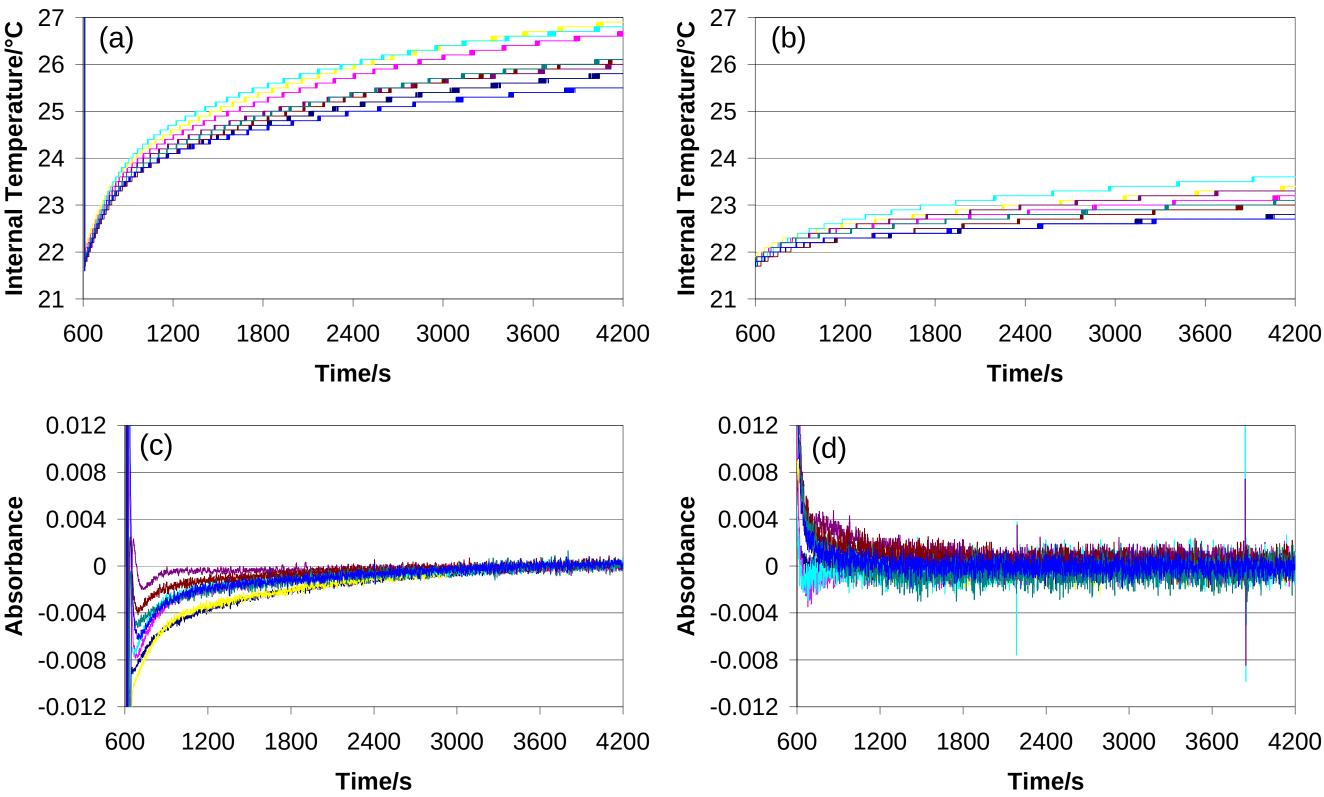

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Figure 1: (a) Internal temperature of 8 IRC-A1 sensors following switch-on with 5V-lamp voltage.

(b) Internal temperature of 8 IRC-A1 sensors following switch-on with 2V lamp voltage.

(c) Absorbance under nitrogen for 8 IRC-A1 sensors following switch-on with 5 V lamp voltage.

(d) Absorbance under nitrogen for 8 IRC-A1 sensors following switch-on with 2 V lamp voltage.

Figure 2 shows the relationship between zero and span rms noise and lamp voltage for an IRC-A1 sensor (0 to 5% Vol, Span = 4 % Vol).

It can be seen that noise is significantly increased as the lamp voltage is decreased, due to a diminishing signal. However, even at 2 V the noise levels remain highly competitive. At 2 V, the span rms noise is <0.35 % of the reading (130 ppm/40000 ppm) and zero noise is <1.2 eq. ppm. For users where resolution is not critical, reduction of the lamp voltage (with concurrent savings in power, lamp life and warm-up time) is an attractive proposition, made possible by the optical design of the IRC-A1.

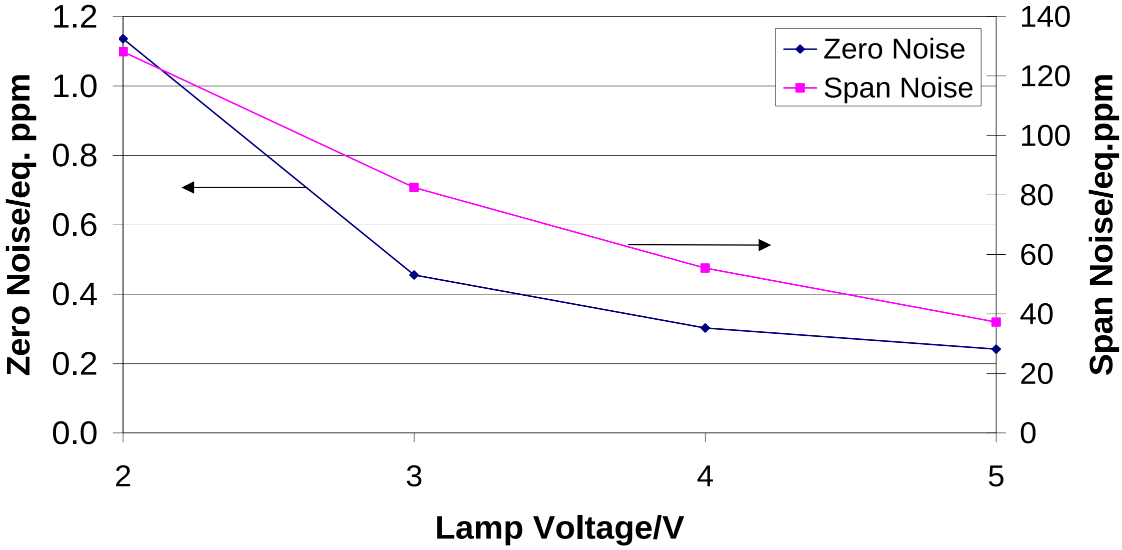

Figure 2:
Plot showing the zero and span noise for an IRC-A1 sensor (0 to 5% Vol, Span = 4% Vol). Noise measured from 50 points at 2 Hz with no software averaging.

Cleaning the lamp
If the halogen lamp is operated for extended periods at a low voltage, the lower temperature of the lamp may mean that the tungsten filament will plate out on the glass of the lamp, reducing the light output.

To alleviate this problem, if you are operating at lower voltages then your gas detector circuit should periodically increase the lamp voltage for a short time to 5VDC.

Good practice would be one minute at 5VDC at switch-on for portable equipment and 2-minutes/ day for fixed/ continuous powered gas detectors.

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