PYREOS

Application Note 1

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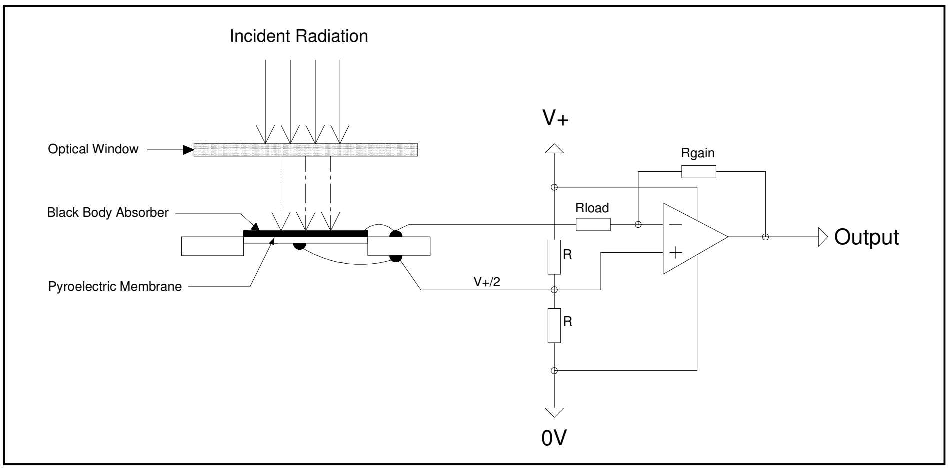
Pyreos pyroelectric detectors are extremely sensitive thermal detectors that produce a voltage output in response to a change in incident radiation. At the heart of a Pyreos detector is a thin sputtered film of a self polarised pyroelectric material. This thin film IR sensor is deposited onto a robust thermal membrane layer substrate. The IR absorbing thin film faces towards an optical window through which radiation enters the detector device. The wavelengths of radiation that enter are determined by the characteristics of the optical window. When using a pyroelectric detector in gas detection, this optical window is commonly a narrow bandpass optical filter, either to select wavelengths suitable for detecting target gas concentrations or to generate a reference wavelength signal. These filters pass wavelengths in the infrared region of the electromagnetic spectrum. However, in principle the optical window can be chosen to suit a variety of applications, and may be a wide bandpass, high pass or low pass to exploit the high sensitivity of the Pyreos pyroelectric detector over a wide range of wavelengths from Terahertz (far infrared) to the UV.

Radiation entering the device is absorbed by the pyroelectric thin film and this generates a small amount of heat in the pyroelectic thin-film.. The change in temperature (temperature difference) generates a charge on the surface of the pyroelectric layer and this charge is converted to a voltage output via a current to voltage trans-impedance amplifier within the detector.

A schematic of the detector shows the major components:



In Pyreos standard range of gas detectors, the output signal is a voltage biased at mid supply with the alternating signal superimposed upon it in response to changing incident radiation. On illumination the output goes below the mid supply level. The small amount of charge generated by the temperature difference between the two surfaces of the pyroelectric thin-film is discharged through the load resistor Rload. This introduces an electrical time constant in the process of conversion. Additionally, the heat generated by absorbing the incident radiation would eventually be transferred through the thin(~1µm) pyroelectric layer to the underlying thermal membrane, reducing the temperature difference between the two surfaces and therefore the amount of charge generated. This introduces a thermal time constant in the process of conversion. Both the electrical and thermal time constants therefore require that the incident radiation needs to be changing in intensity in order to generate a continuous signal.

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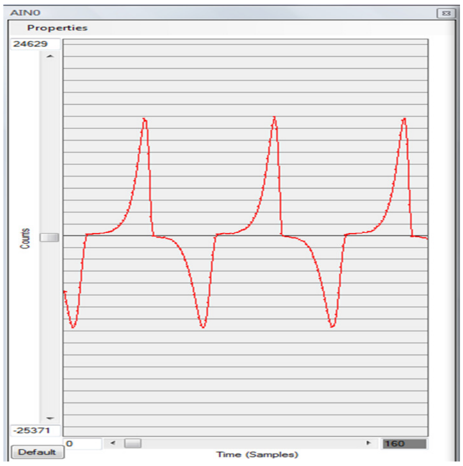
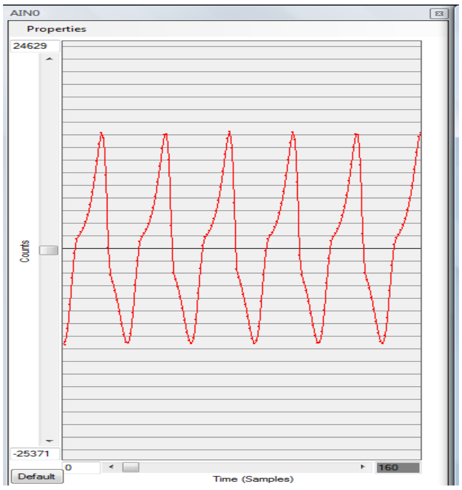
The effect of both time constants is evident in the shape of the output signal as a function of frequency of oscillation of the incoming radiation. Typically radiation is chopped or pulsed in order to maintain an oscillating signal output centred on the mid supply voltage. The shapes of the signals therefore vary with the illumination frequency where the duty cycle of the illumination should be set to 50% to balance the illumination time with the dark time.

Typical signal waveforms are shown below. These were obtained using a Pyreos evaluation kit with a Pyreos black body radiation source pulsed at 50% duty cycle running with Pyreos evaluation kit software. The detector was a Pyreos CO_2 dual element detector running in nitrogen at room temperature. The active and reference signals have essentially the same shape. Note that the time axis is in terms of samples with the earlier samples on the right:



Illumination frequency = 2Hz:

The initial response is progressively overcome by the electrical time constant and the signal decays back towards the mid supply reference voltage. At 2Hz this return to the mid supply voltage is almost complete. The peak to peak magnitude is approximately 23500 counts and the RMS value is approximately 5750 counts.



Illumination frequency = 4Hz:

As the illumination is toggled at a faster rate the decay to the mid supply point is still evident but not as extreme as at 2Hz. The peak to peak magnitude is approximately 25300 counts and the RMS value is approximately 7650 counts.

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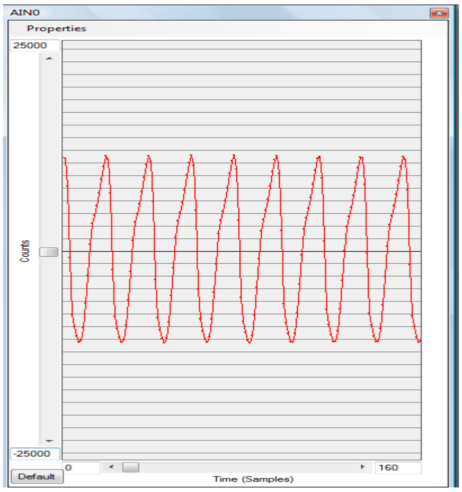
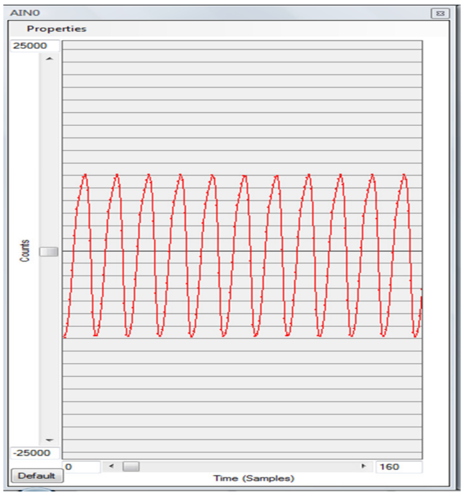


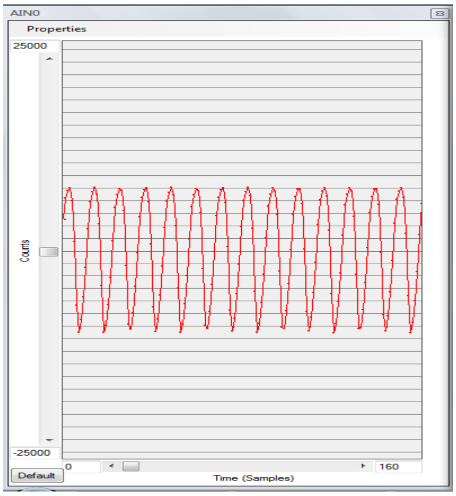
Illumination frequency = 6Hz:

The decay from the maximum signal is less than at 4Hz as the illumination oscillation frequency increases. The peak to peak magnitude is approximately 22300 counts and the RMS value is approximately 7900 counts.



Illumination frequency = 8Hz:

The waveform is becoming dominated by the illumination oscillation frequency and the decay from maximum excursion is much reduced. The peak to peak magnitude is approximately 19500 counts and the RMS value is approximately 7250 counts.



Illumination frequency = 10Hz:

The illumination frequency now dominates and the signal shows little decay from maximum excursion. The peak to peak magnitude is approximately 17300 counts and the RMS value is approximately 6300 counts.

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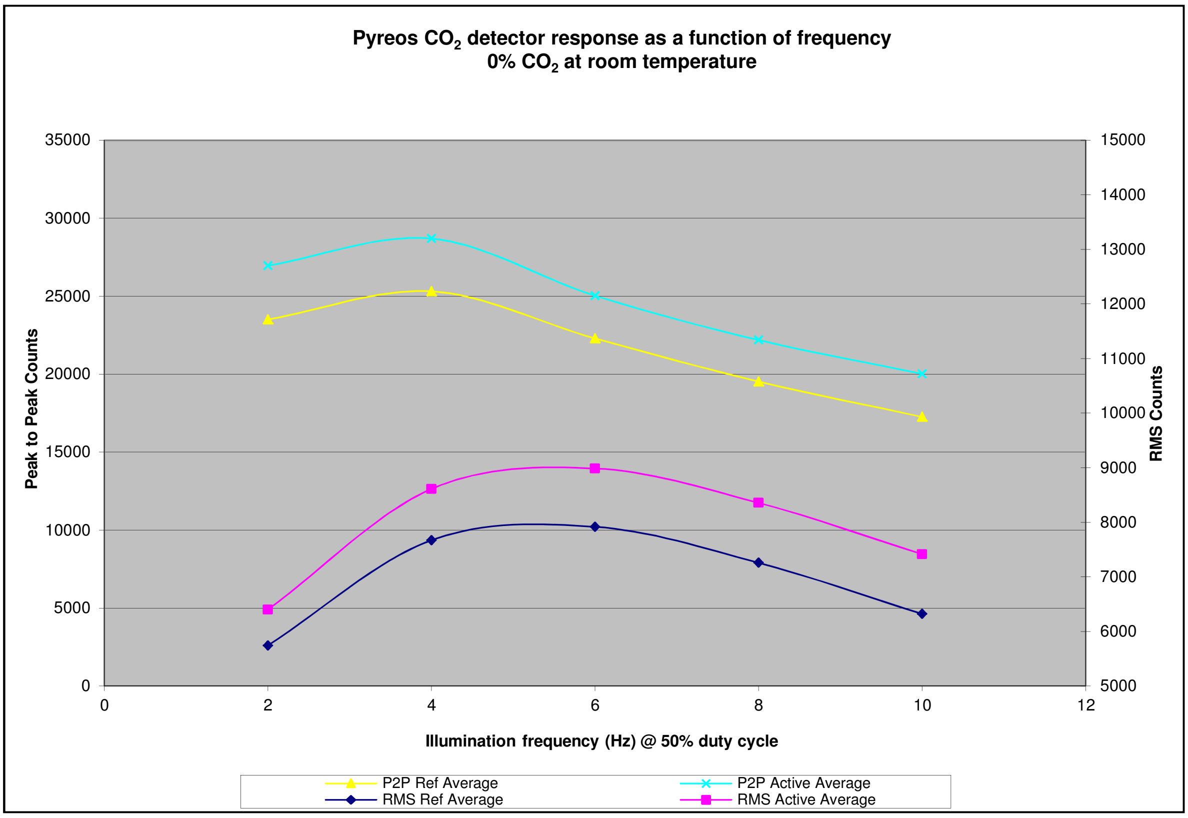
The signal size varies with frequency along with the signal shape as a consequence of the time constants decay reducing with increasing frequency but with the absorbed energy per cycle also reducing with increasing frequency. This is summarised in the following diagram:



The distortion of the wave shape at low frequencies means peak to peak measurements are dominated by the time constants of the detector whereas at higher frequencies the wave is more symmetrical. Although the peak to peak magnitude reduces with increasing frequency it is preferred that peak to peak measurements be made at frequencies in the region of 10Hz. However, the RMS responsivity is less affected by frequency and shows a plateau in the region of 5 - 6Hz.

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