InfraTec

Frequently Asked Questions

How does a pyroelectric detector work?	When light radiation (UV, VIS, IR, THz) is applied to a thin pyroelectric crystal (<40µm) its temperature increases by fractions of a degree centigrade. Turning on the radiation an electrical charge is generated by heating, turning off the light the crystal cools down and an opposite charge is generated. These very small electrical charges are generally converted within the detector housing to convenient signal voltages by use of extremely low noise and low leakage Field Effect Transistors (JFET) or CMOS operational amplifiers (OpAmp). It is very important to remember that only modulated radition creates a signal, therefore either pulsed or mechanically chopped IR sources are used and unmodulated disturbing background radiation is filtered out.
In what wavelength range do pyroelectric detectors operate?	As the thermal effect of the incoming radiation is used to produce the electrical detector response, electromagnetic radiation from deep UV (100nm) over the visible range to the far infrared up to the THz range (1000µm) can be detected, as long as the pyroelectric crystal is covered with a suitable absorption layer. InfraTec use two different coating technologies for black absorbing layers. The polymer black coating is used for most detectors and offers extremely stable long term absorption from UV up to 100µm IR even for high modulation frequencies (max 4kHz). A special metal black coating is used especially for spectrometer detectors and is characterized by an extremely flat and high absorbance but is sensitive for operating temperatures >60°C, high radiation power as well as strong vibrations.
What are pyroelectric detectors used for?	A pyroelectric detector can be used very exactly and with long term stability to measure IR radiation. As the pyroelectric element only reacts to a change of the IR radiation the detector must always be used with a modulated (mechanically chopped or electrically pulsed) radiation source. Since pyroelectric detectors operate on a thermal phenomenon they have a very broad spectral response - between 100 nm to over 1000 µm without any cooling like semiconductor detectors. Most common applications are motion detection, NDIR gas analysis, flame detection with spectroscopy and radiometry also possible. Even if pyroelectric detectors are thermal detectors they are able to measure signals up to some kHz with high performance. Short pulses can be detected down to some µs (microseconds) but with considerable loss of signal-to-noise.
What is a NDIR gas analyzer typically made of?	A large number of materials absorb infrared (IR) radiation due to intramolecular vibrations. For any specific material the strength of absorption varies with the wavelength of the infrared radiation. This principle is often used in gas analysis. An NDIR (Non Dispersive IR) gas analyzer contains an electrically or mechanically modulated IR source, a gas chamber with the gas of interest and a pyroelectric detector. Normally a standard narrow bandpass filter (NBP) that matches the absorption wavelength of the target gas is integrated in the detector cap and simplified the gas sensor design.

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How does a flame sensor work?	The pyroelectric detector of a flame sensor is detecting the typical spectral radiation of burning organic (hyrdocarbon) materials (wood, natural gas, petrol, plastics). Two criteria are used to distinguish a flame from the sun or any other light source. 1) A typical fire is "self-modulated" around 10Hz by flickering. 2) A hydrocarbon flame is producing the combustion gases of carbon CO and CO_2. The emission bands of CO_2 and CO in the infrared range are between 4.0 and 4.8µm. A built-in IR bandpass is passing only the emission bands of both CO_2 and CO to the pyroelectric element. Computing both flicker frequency and spectral information 4.0-4.8µm will suppress false alarms effectively.
Is it possible to use pyroelectric detectors which contain neither a JFET nor an OpAmp thus only the pyroelectric element in gas analysis and flame detection?	The charges created in the pyroelectric crystal are very small and need to be amplified by preamplifiers with very high input impedances (up to some 10 GOhm). At ambient conditions (for example 60% relative humidity and 23°C) such circuitry cannot be operated without disturbances. At least the high impedance part of the circuitry should be within the hermetically sealed detector housing. We therefore recommend using detectors with integrated JFET or OpAmp for gas analysis and flame detection.
Is it useful to cool down pyroelectric detectors for example by using a Peltier device to improve the signal-to-noise-ratio?	No. Pyroelectric detectors unlike PbS or PbSe detectors do not need any cooling even for the detection of longwave radiation in the range of 8-14 µm. But operating temperatures of over 50° C do however increase the detector noise, as the integrated amplifier components exhibit larger leakage currents at higher temperatures. It is noteworthy that CMOS OpAmps react much less as JFET's, as the gate leakage current of a JFET increases exponentially with temperature. For applications with operating temperatures above 60°C always consider the use of detectors with CMOS operational amplifiers.
Is it useful to heat pyroelectric detectors to improve the signal-to-noise-ratio?	No! Pyroelectric detectors for FTIR spectrometers are sometimes operated at higher temperatures of about 50°C because here a special pyroelectric crystal (DTGS) is used instead of $LiTaO_3$ used by InfraTec. This DTGS crystal material has a Curie temperature of about 59°C, $LiTaO_3$ shows 620°C. Near to the Curie temperature the pyroelectric coefficient and resulting signal voltages are growing remarkably but with the side effect of a very high temperature coefficient. A visible signal increase by warming the $LiTaO_3$ detector is not possible due to the very high Curie temperature but otherwise the temperature coefficient of $LiTaO_3$ is extremely low. Heating of $LiTaO_3$ detectors (40 ... 60°C) is only common for gas analyzers to avoid a condensation of wet gases or to reduce the optical filter drift by temperature stabilizing.
In which temperature range is it possible to use pyroelectric detectors?	InfraTec uses single crystalline $LiTaO_3$ polished on both sides as pyroelectric material. This permanently polarized material has a Curie temperature of 620° C and therefore does not limit the usable temperature range. The maximum operating temperature of the detector is therefore mainly limited by the parameters of the integrated preamplifiers. The mechanical properties of the built-in IR filters or windows and its assembling technology limit the minimum and maximum storage temperature.

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Is it possible to work at operation temperatures over 100° C?	Principally this is no problem for the pyroelectric element itself, however care has to be taken when selecting the electronic components like resistor, JFET an OpAmp as these have to meet the increased specification. Additionally the built-in IR filter or window has to be designed for and its mounting technology must be able to guarantee a long term hermetical sealing by buffering mechanical tensions. A combination of both high (>85°C) and very low temperatures (<-25°C) is difficult. For applications with operating temperatures above 60°C always consider the use of detectors with CMOS operational amplifiers instead of JFET because their leakage current is lower.
What are the meanings "microphonic effect" or "acceleration response" as used for pyroelectric detectors?"	All pyroelectric materials are always also piezoelectric. Therefore the pyroelectric chip in the detector reacts on impact sound or airborne sound like a microphone or an acceleration sensor. This behavior is known as the microphonic effect or acceleration response, sometimes also as microphonic noise. This disturbing effect can be compensated for very well by an InfraTec patented pyroelectric chip mounting (so called low-micro technology).
How does InfraTec reduce the "microphonic effect" or "acceleration response" of pyroelectric detectors and what are the meanings of "lowMicro" or "ultra low microphonic effect" used for pyroelectric detectors from InfraTec? "	The airborne sound can be suppressed by the hermetically sealed detector housing. The interfering impact sound can be reduced by an appropriate mechanical mounting of the pyroelectric chip in that way, that the physically caused piezoelectric charges will be compensated. In 2004 InfraTec introduced new detector families for which a patented micromechanic chip mounting (abbreviation lowMicro) is reducing the acceleration response remarkably. These detectors are characterized as LME (single channel) or LMM (multi channel) instead of LIE or LIM, where the second "M" stands for Low-Micro.
What is the purpose of "thermal compensation?"	The DC output voltage (operating point) of the pyroelectric detector (JFET or OpAmp) can be stabilized in temperature ramps by about a factor 20 with the use of a blind, golden-mirrored antiparallel connected pyroelectric element. This helps to shorten the warm up phase or to increase the accuracy of a handheld IR system. Thermal compensation is very common for gas analyzers, less common for flame detection, not common for spectrometers.
Which temperature issues cannot be solved by using "thermal compensation?"	The temperature compensation does not help to compensate the temperature drift of the integrated IR filter. The temperature coefficient (drift) of the signal voltage and gas concentration measurement can also not be decreased.
What does "Voltage mode detector" mean?	In voltage mode the pyroelectric current charges the pyroelectric element capacitor, and the resulting voltage is measured by a source follower (JFET, gate resistor and external source resistor). At common modulation frequencies between 1-10 Hz voltage mode detectors operate beyond the thermal and electric time constant in 1/f behavior, typical signals are a few mV.
What does "Current mode detector" mean?	In current mode the pyroelectric current is transformed by a Current-Voltage-Converter (mainly OpAmp with feedback components, also called a Transimpedance-Amplifier TIA). Current mode detectors normally operate between both thermal and electrical time constant at frequencies from 1Hz up to 1 kHz, with typical signals about 100 mV or more. Current mode is the more modern operation mode because there are some advantages.

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What are the main differences of Voltage and Current mode operation?	For the detector performance the frequency response defined by thermal and elecrical time constant and the resulting signal is of key importance. The thermal time constant (typically 150 ms) as a measure of the thermal coupling of the pyroelectric element to the environment is effective in both operation modes. The electrical time constant in voltage mode is defined as the product of the pyrochip capacitance and the gate resistor and can be changed only in a small range. In current mode it is defined as the product of feedback resistor and feedback capacitance. Additionally the achievable gain of the pyroelectrical signal in current mode is much higher and can be adjusted easily by changing the feedback resistor, while in voltage mode the gain is only around 0.8. Therefore in current mode the frequency response and signal voltage of the detector can be designed much more individually, which results in possible operation at high frequencies up to 1kHz resulting in a very short response time.
How does it effect the performance of a voltage mode detector when changing the gate resistor?	The reduction of the gate resistor in an uncompensated voltage mode detector is a convenient method to increase the stability of the Offset voltage in temperature ramps. It is therefore often used if a thermal compensated detector is too expensive. However, a reduced gate resistor produces an increased noise proportional to 1/sqrt R. Rule of thumb: By a thermal compensation the detectivity of an uncompensated detector decreases to 70%. For a similar stability an uncompensated detector has to be designed with a 1/16 of gate resistor (e.g. 5GOhm instead of 82GOhm), means the detectivity decreases to sqrt of 1/16 = 1/4. A thermal compensation is about 3 times better than reducing the gate resistor.
How is it possible to check the functionality of the detector?	Nearly all detectors supplied by InfraTec contain a preamplifier composed of a JFET source follower or a CMOS-OpAmp. In both configurations an easy test of the functionality is to check the DC output voltage of the detector. In a thermal steady state and without an IR source the measured DC output voltage shall agree with the Offset voltage displayed in the measurement report supplied together with the detector. In addition, when heating the detector carefully with the finger or a hot air stream a clear changing of the DC output voltage should arise. Normally, a voltage mode detector (JFET) shows a DC-shift to the positive direction, a current mode detector shows a negative DC-shift.
What are the advantages of beamsplitter detectors?	In a beamsplitter detector the IR radiation is entering one aperture window and is divided internally by a beamsplitter in two or four parts. Due to the single aperture only a Ø 2.5mm area needs to be illuminated and thus smaller gas cells with a small gas volume can be used. Additionally, the signal ratio of all channels in the detector is stable, independent from aging, mechanical shift or pollution because a partial illumination of the entrance aperture effects all channels similarly.

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What if more than 4 channels or wavelengths need to be monitored. Is a second detector necessary?	Normally, 3 gas channels and a reference are monitored with a 4 channel detector. If you need to monitor more than 4 channels you have different options. Often two different 4 channel detectors are used in parallel using an external uncoated Si beamsplitter in front of them. Alternatively, a single channel detector with a filter wheel having the number of needed NBP filters for each spectral channel (up to 8 channels are common) can be applied. A more sophisticated possibility is to use InfraTec's Fabry-Perot detector LFP where a continuous spectrum can be scanned. Two types of detectors are available LFP-3041L-337 (tuning range 3..0...4.1µm) and LFP-3950L-337 (tuning range 3.9...4.8µm)
Is a reference channel always necessary for a gas analyzing sensor?	A reference channel is useful in NDIR gas analyzers to compensate optical (IR source), mechanical and electronic longterm drifts as well as drifts by contamination of the optical path. This reduces the need for re-calibration. The signal in the gas channel(s) will be normalized by the reference signal and so most of the variations will be eliminated. The spectral position of a reference channel should be as close as possible to the gas channel(s) to improve the "normalizing effect". In many cases one reference channel can be used for all gas channels of a multi-gas analyzer. A reference channel is however not needed if there are other possibilities to compare the sensor signal with gas presence and without measuring gas, for example by changing the gas in the cuvette periodically.
What is the maximum distance an InfraTec detector can detect an IR radiation?	This depends on the detectivity of the detector and eventually additional optics in front of it. Distances of up to 100 meters are common in flame detection. To cover large distances current mode detectors with large pyroelectric elements are useful.
Are there advantages to using a pulsed IR source over a "chopper?"	A pulsed thermal IR source is a state-of-the-art solution as no moving parts in the device construction are necessary. Please note that electric pulsing is a modulation of the radiation power AND the spectral characteristics according to PLANCK's law. It can however be used only for modulation frequencies up to a few ten Hz as the modulation depth of the thermal source goes down dramatically with increasing modulation frequency. For larger frequencies - for example 100 Hz - or for an exact radiation power modulation a mechanical chopper is recommended.
What protects InfraTec devices from moisture and other contaminants?	All InfraTec detectors are filled with dried pure nitrogen and hermitically sealed by welding the detector cap with the socket. The IR filter windows are glued with high resistive and low outgasing epoxy into the cap.
What is the meaning of RoHS (2002/95/EG), WEEE (2002/96/EG) and REACH (EG 1907/2006)?	RoHS, WEEE and REACH are three important European guidelines to protect our environment. RoHS specifies six banned chemical substances such as lead, mercury and cadmium. WEEE (Waste Electrical and Electronic Equipment) determines how to handle used electric and electronic devices. REACH appoints to the interdiction using listed Substances of Very High Concern in products and production processes.
Are InfraTec's pyroelectric detectors and their production process in accordance with RoHS, WEEE and REACH?	All device manufacturers who supply goods inside the European Union have to assure conformity with the three EU guidelines RoHS, WEEE and REACH. It is a part of our Green Policy that InfraTec as component supplier to certify to the device manufacturer, that the IR detectors and their manufacturing process fulfill all the three EU guidelines.

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