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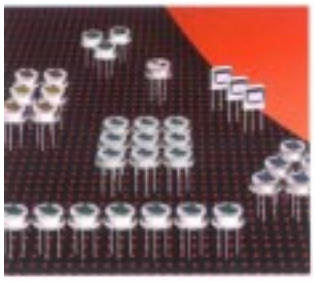
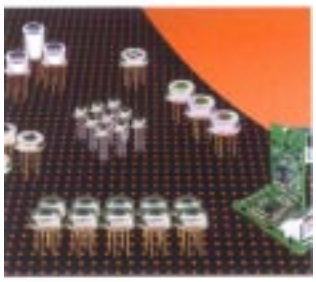
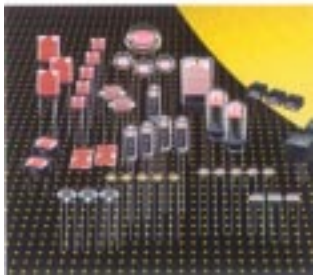
- a design guide line -

1/02

Frequency Range for Pyroelectric Detectors







Application Note

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Frequency Range for Pyroelectric Detectors for Motion Sensors

The basic idea of motion detection with passive infrared detectors combines two items in a very clever way: A detector component which senses mid to far infrared radiation, and a focussing optical system which divides the room into sections. The pyroelectric detector acts only on modulation of IR radiation.

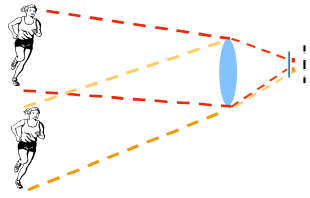
A simple mirror facet system, or a fresnel lens focuses radiation towards this detector. When the radiation moves from it's location to another location, the detector receives this modulation, and thus generates the output signal. This is the working principle of movement detection.

Motion sensors have conquered worldwide applications in Security and Home Automation markets. Passive intrusion alarms, door openers, automatic lights and security lights have contributed to more comfort and security.

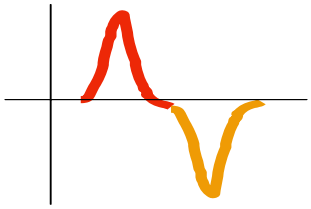
All the devices that offer such function apply a pyroelectric dual element detector - see recommended type list below - in combination with a multi-facet mirror, or a multisegment fresnel-lens.

Type	Kind	Application
LHi 878	dual element	Light switch
LHi 958	dual element	Standard intrusion alarm
LHi 968	dual element	High perfoormance intrusion alarm
LHi 906	dual special element	Ceiling mount apllications

The lens system determines the range of the sensor and divides the objected area into segments. Most of the units offer a close up area, a mid range area and a far range area, all of them segmented into radial partitions. The lens focuses the individual partition to one of the active elements of the pyrodetector.



If now man walks through the objected area, he crosses the individual sections, and his radiation is focused alternating to first and second element. The detector generates a signal output . This signal is of an AC voltage shape as shown here:



What is the influence of the walking to the signal in frequency and amplitude? How to design the best suited electronic circuitry?. We find that the output signal depends on:

- distance of human body to the motion sensor
- walking speed of human body
- focal length and pattern design of the optical system

To begin with we now consider one of the most common use of passive iR detectors which is Infrared Intrusion Alarm.

For this application certain rules and standards have been set in the individual countries. In the U.S.A. facilities recommend UL approval, Great Britain alarm installers and manufacturers take reference to British standards, in France AVNOR sets the rules and the Germany VDS approval has become a recognized guiding line for Europe in general.

The requirements all stipulate that very fast movements and extremely slow motions of intruding bodies have to be detected.The slow motions range at about half a meter per second, whereas fast motions can be up to 3 meter per second , or even 5 m/s (18 km/h).

The iR detector's output signal will respond in a certain frequency range depending on the focus of the optical system and the walking speed , which is to be calculated when designing the electronic circuitry. A very good rule of thumb can be the use of the formula below or reference to the table next page for the relation between velocity, focus and frequency:

$$f = \frac{v_b * f_b}{2\pi * s * L}$$

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f_b = *focal length (mm)*
f = *frequency (Hz),*
V_b = *velocity, walking speed (m/s)*
s = *size of sensing element*
L = *working distance*

For dual element detectors there is a standard element size which is 2mm x 1mm, the value to be included in the calculation for s is the vertical size which is 1 mm

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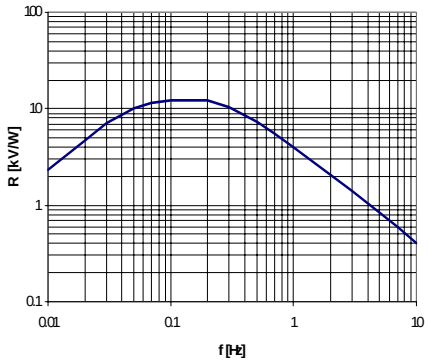
We find that a typical frequency range for signals will be 0,08 Hz ...8 Hz with a typical fresnellense of 25 mm focal length. The low frequency range is determined by the movements in far distance, the high end is caused by fast movements close to the detector.

Is the pyrodetector suited for this range?

From the formula calculation, or from the table below, we conclude we need maximum sensitivity in far distance, which generates the frequencies at 0,1 Hz.
The sensitivity definition for such optical detectors references the term Responsivity, which is the sensitivity per area, under specified test conditions. Please see responsivity curve of a typical pyrodetector, series LHi 968, below:



Frequency response LHi 968

The graph is showing maximum sensitivity around 0.1 Hz, which grants detection of movements in long distance. If the walking distance of the body is closer to the device, the radiated power exposed to the iR sensor is higher and thus the signal increase compensates the 1/f decrease of responsivity.

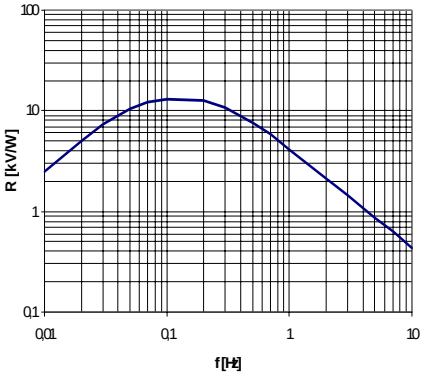
We conclude this detector is very well suited for this working range. Further, we may conclude that the rules about moving bodies, set for intrusion alarms, are almost 1:1 applicable for other applications, unless we want to exclude fast movements (for example animals in outdoor applications, or low movements like hot air turbulances).

The frequency range may differ slightly from case to case, but they all should be very similar. Consequently, the responsivity graphs from the recommended types all are very similar.

Frequency versus velocity with various focal lengths

V_b(m/s)	L (m)	f (Hz)			
		f_b=20mm	f_b=25mm	f_b=30mm	f_b=40mm
0,3	0,5	1,91	2,39	2,86	3,82
0,5		3,83	3,98	4,77	6,37
1		6,36	7,96	9,55	12,7
5		31,8	39,8	47,7	63,6
0,3	1,5	0,64	0,80	0,95	1,27
0,5		1,11,06	1,33	1,61,59	2,12
1		2,12,12	2,65	3,23,18	4,24
5		10,610,6	13,2	1615,9	21,2
0,3	7,5	0,13	0,16	0,19	0,25
0,5		0,21	0,27	0,250,32	0,42
1		0,42	0,53	,50,64	0,85
5		2,12	2,65	2,53,18	4,24
0,3	12	0,08	0,10	0,12	0,16
0,5		0,13	0,17	0,20	0,27
1		0,27	0,33	0,40	0,53
5		1,33	1,66	1,99	2,65
0,3	16	0,06	0,07	0,09	0,12
0,5		0,10	0,12	0,15	0,20
1		0,20	0,25	0,30	0,40
5		0,99	1,24	1,49	1,99
0,3	25	0,04	0,05	0,06	0,08
0,5		0,06	0,08	0,10	0,13
1		0,13	0,16	0,19	0,25
5		0,64	0,80	0,19	1,27

The guideline how to choose the best suited detector is to check on all the other parameters besides responsivity. The field of view, and the safety against various disturbances detremine requirements, which will be met by special types; we will discuss this issue at a later edition. There are also different shapes of element configurations available. For reference, the responsivity graph of series LHi 878 is shown here, it is very similar to the LHi 968.



Frequency response LHi 878

Our considerations have included a lense design with 25mm focus. Typical lenses offer focal lengths between 20mm and 30mm, while special designs such as corridor lens or curtain lenses may offer higher focal lengths. The table given hereby offers data for various designs to give an idea what the optical system can effect to the electronic circuitry.

Conclusion:
Working range and focal length of the optical system mainly determines the frequency range of all motion sensor applications. It will be essential to choose the correct lens system for a defined working range. Pyrodetectors as thermal detectors with a rather slow frequency response are perfectly suited for this application. PerkinElmer Optoelectronics offer a variety of types of pyrtodetectors to present the best possible solution to the individual application..

Current types of pyrodetectors for motion sensors

LHi 878	Dual Element Standard
LHi 958	Dual Element
LHi 968	Dual Element High Performance
LHi 1128	Ceiling mount Four Element Type
LHi 908	Ceiliing Mount, two round elements
LHi 1148	Quad Four Element Type, reverse
LHi 1448	Twin Four Element Type
LHi 1548	Twin Four Element Type, reverse
LHi 333	Dual Element, Flat Pack

Current types of pyrodetectors for other sensors

LHi 807	Single Element Standard
LHi 807TC	Single Element, thermally compensated
LHi 808	Single Element
LHi 808TC	Single Element, thermally compensated
LHi 814	Dual Channel, with individual narrow band windows

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