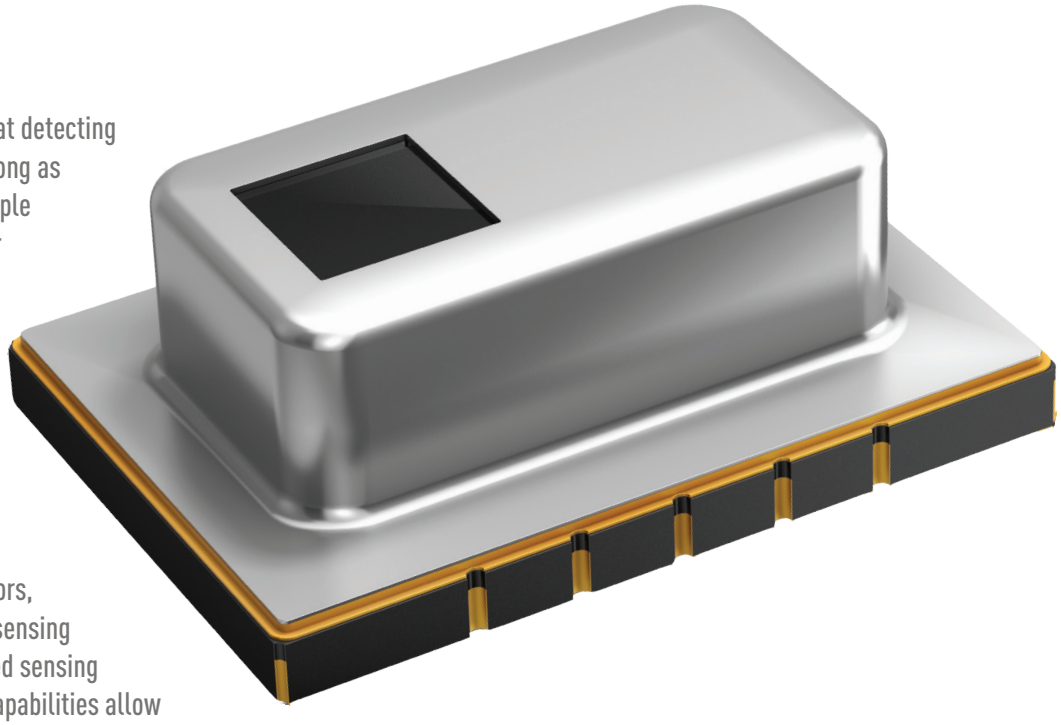
Panasonic

SENSORS

Thermopile Arrays Enable New Generation of Automation Systems



Passive infrared (PIR) sensors do a good job at detecting the presence of warm bodies in a room—as long as those bodies are moving. However, these simple sensors won't detect motionless objects. Nor can they tell you the direction of any movements within their field of view. To get around these sensing limitations, you need a more sophisticated passive IR sensing technology known as a thermopile array.

Instead of the single sensing element employed by conventional PIR motion detectors, the thermopile array consists of multiple IR sensing elements working together. These coordinated sensing elements and integrated signal processing capabilities allow the thermopile array to measure absolute temperatures as well as temperature gradients. PIR motion detectors, by contrast, can only pick up changes in temperature within their field of view, which is why they can't reliably detect bodies at rest.

The coordinated sensing elements of a thermopile array can do more than just read temperatures. They can also pick up the direction of movement—up, down, left, right and diagonally. Thermopile arrays can even detect multiple people or objects as they move in different directions. They can also sense an object's proximity to the detector and handle simple gesture control tasks.

The thermopile array's enhanced sensing capabilities may be overkill for simple building automation applications, which have traditionally relied on low-cost PIR-based motion detectors. Yet building automation systems are becoming more sophisticated and increasingly require the ability to sense motionless objects, multiple objects and direction of motion. These enhanced sensing capabilities can also support emerging object detection applications in industrial medical and retail settings.

Here's a more detailed look at thermopile array technology, some of the implementation options and the emerging applications that can benefit from this sensing technology.

THERMOPILE ARRAYS EXPLAINED

There are several variants of thermopile arrays available in different sizes and electronics packages, depending on the intended use. Panasonic's popular version, the Grid-EYE, currently consists of 64 MEMS thermopile elements arranged in an 8x8 grid on a single detector chip. An integrated circuit for signal processing and thermistor round out Grid-EYE's onboard electronics.

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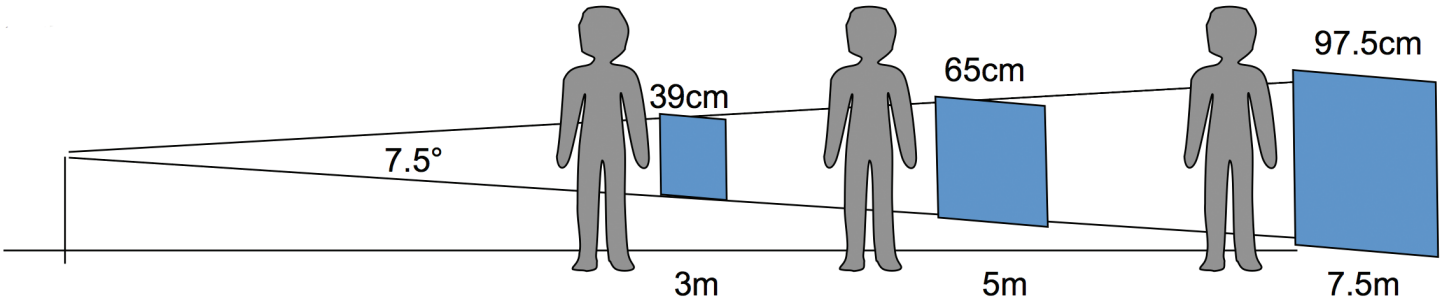


GRID-EYE sensors can detect human beings across a range of distances.

The entire thermopile array fits within a reflow-compatible surface mount (SMD) package consisting of an RF-shielded metal cover, ceramic base and an integrated silicon lens through which the infrared energy passes. Grid-EYE offers I2C digital output for direct transmission of temperature values to a microprocessor.

In operation, Grid-EYE first absorbs emitted thermal energy across a 60-degree field of view. Each one of the array's 64 sensing elements converts the thermal energy it absorbs to a proportional output signal. All 64 temperature signals are then amplified, converted from analog to digital and referenced against an ambient temperature value supplied by the thermistor. The sensor electronics then push the resulting temperature readings to a microprocessor via the I2C interface.

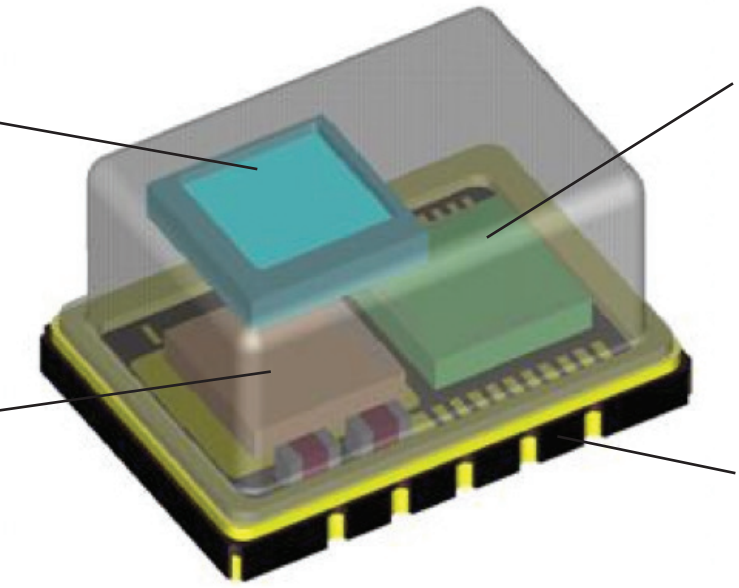
Finally, the microprocessor performs calculations that map temperatures from the individual thermopile elements into a complete thermal representation of the entire field of view. Changes in this representation over time indicate direction of motion. Panasonic's versions of thermopile arrays work in both horizontal and vertical orientations with a maximum recommended detection distance of 5 meters and frame rates up to 10 fps.

Depending on the application, thermopile arrays can be ordered in a high-gain version that measures temperatures to within 2.5ºC while offering a temperature range of 0 to 80ºC. A low-gain version of the same 64-element sensor offers a wider sensing range of –20 to 100ºC, but it offers a slightly reduced accuracy of ± 3ºC.

GRID-EYE FEATURES

Silicon Lens
- Image formation

IR Detector
- 8 × 8 pixels
- Thermal insulation structure using MEMS technology
- Infrared absorption
- Thermoelectric conversion



Mixed Signal Processing IC
- 64-pixel signal readout
- Analog amplification
- Analog to Digital conversion
- Sensitivity correction
- Correction for temperature effects
- Digital communication

Ceramic Package
- Air tight
- Radio shielded
- Reflow available

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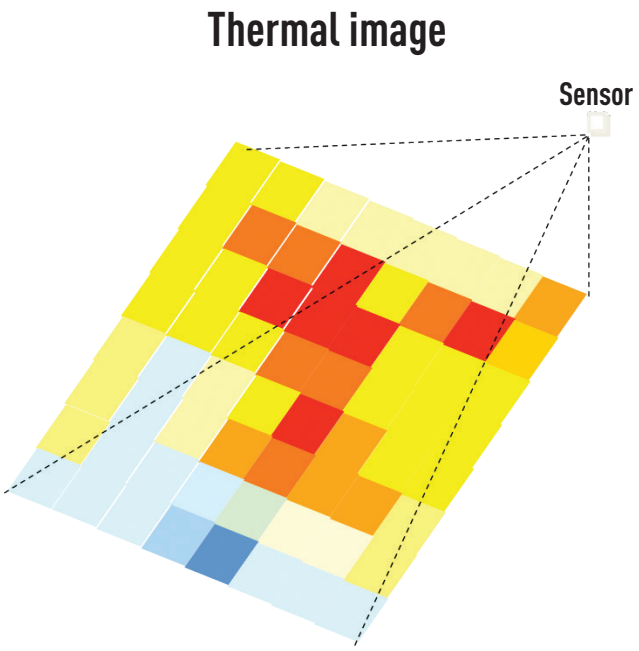
RICHER DATA ENABLES NEW APPLICATIONS

While thermopile arrays and traditional single-element infrared sensors both qualify as passive sensing methods, the two could not be more different from an application standpoint. While traditional PIR sensors offer a low-cost way to detect the presence or absence of a warm body, that's as far as they can go.

By adding the ability to detect direction of motion and the presence of motionless bodies, thermopile arrays open up a world of automation applications that would be impossible with a traditional PIR sensor.



GRID-EYE's thermopile array is eight-by-eight pixels, which creates a 64-pixel thermal image.

In fact, the closest points of comparison to a Grid-EYE sensor aren't really single element PIRs but far more expensive active sensing devices or vision systems.

Applications that can benefit from richer sensor data on motion, proximity and stationary object detection without the need for more expensive active sensing options include:

Building Automation. Detecting whether people have entered or left a room is a fundamental task for simple building automation systems that seek only to turn lights and environmental system on or off automatically. With the enhanced motion and proximity data from a thermopile array, building automation systems with more complex logic become possible without moving to prohibitively expensive sensors. For example, rather than a simple on-off automation of lighting controls, the automation system may use information on movement, number of occupants and position in a room to make targeted adjustments to lighting and air conditioning systems.

Manufacturing and Industrial. The use cases on the factory floor start with entryway and device control. Clean rooms in particular can benefit from these capabilities. Manufacturers are also testing Grid-EYE thermopile arrays as a way to sense the movement of goods on production lines—including one application that involves a liquid filling operation. Keep in mind, though, that the thermopile array's frame rate and response time will limit its utility in some high speed applications. The most promising applications on the factory floor involve the marriage of thermopile arrays with robotic systems or automated guided vehicles. The ability to detect a worker's location and direction of movement could allow them to work in closer proximity to robots while improving safety.

Thermopile Array Advantages

Detection Type	Moving Object	Motionless Object	Moving Direction	Temperature Distribution	Thermal Image
Thermopile Array	Yes	Yes	Yes	Yes	Yes
Pyroelement	Yes	No	No	No	No
Single-element Thermopile	Yes	No	No	No	No

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GRID-EYE SPECIFICATIONS:

- 8x8 (64) pixel
- Digital output
- Direct connection to microcomputer
- SMD package
- Reflow available
- Power voltage: 3.3V ±10%, 5V ±10%
- Current consumption: 4.5mA (normal), 0.8mA (standby), 0.2mA (sleep)
- View angle: 60 degrees (x,y)
- Absolute temperature accuracy:
  - High gain: ±2.5ºC (typ.)
  - Low gain: ±3ºC (typ.)
- Frame rate (selectable): 1 frame/sec or 10 frames/sec
- Operating temperature range:
  - 0 ~ 80ºC (high gain)
  - -20 ~ 80ºC (low gain)
- Detection temperature range:
  - 0 ~ 80ºC (high gain)
  - -20 ~ 100ºC (low gain)
- External interface: I2C, 12bit (Inter-Integrated Circuit)

Security. PIR-based motion sensors can give you a rudimentary head count as people walk through the sensor's field of view. But thermopile array is a better approach for accurately counting a mix of moving and stationary occupants in a room. Detecting the direction of movement also has desirable implications in security applications.

Medical Imaging. Passive thermopile arrays can detect not just the presence of patients in medical imaging systems but also whether the patient is moving and correctly positioned in the machine. The sensors can also control lighting within the imaging machine.

Retail. Many retailers already employ simple motion-based systems to count how many shoppers enter and leave a store. Thermopile arrays can provide more detailed information about where shoppers spend their time in the store, revealing which aisles or brand displays are the biggest draws. At the same time, the passive thermopile arrays don't reveal personalized data as a vision-system would, which is important from a privacy standpoint.

These are just a few of the applications possible with thermopile arrays. Expect more in the future as automation developers take advantage of the thermopile array's ability to sense motionless objects, direction of movement and proximity without the high costs of active motion sensors and cameras.

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