# Amphenol Advanced Sensors

# Thermometrics Infrared Thermopile Sensors

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# Infrared Thermopile Sensors
# Non-contact Temperature Measurement

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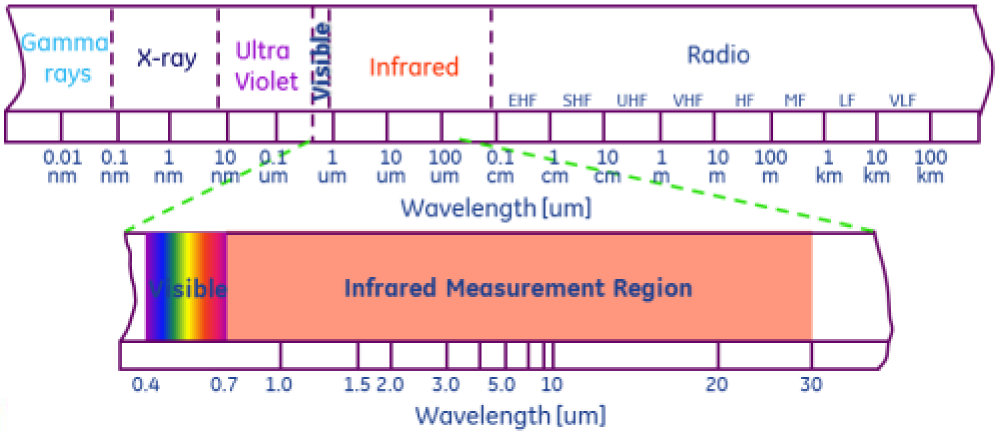
# Infrared Thermopile Sensors

## What is Infrared?

- Form of electromagnetic wave
- Extends from 0.7 µm -1000 µm
  - Near infrared: 0.7 µm - 2.5 µm
  - Intermediate infrared: 2.50 µm - 25.0 µm
  - Far infrared: over 25.0 µm
- Most IR sensors based on two regions … 3 - 5µm and 8 - 12 µm

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# Infrared Thermopile Sensors
## Infrared Radiation

- Electromagnetic emission and absorption
- Occurs at the speed of light
- Travels in a straight line
- Takes place across a vacuum
- Passes through many crystalline, plastic, gaseous materials
- Does not penetrate metals

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# Infrared Thermopile Sensors

## Radiated Infrared Energy

**The warmer the source, the more energy it emits**

$$W = \delta \varepsilon T^4$$

W = Radiant flux emitted per unit area ($W/cm^2$)

δ = Stefan-Boltzmann constant

ε = Emissivity

T = Absolute temperature of target (K)

**As the temperature of the source increases, the wavelength at which most of the energy is radiated decreases**

$$\lambda_{max} = b/T$$

b = Wien's displacement constant

### Infrared Sensing

- Hot objects emit infrared (IR) and visible radiation as a function of surface temperature
- As an object gets hotter, not only does it radiate more, but the peak wavelengths it emits get shorter
- Objects have different wavelengths of radiation

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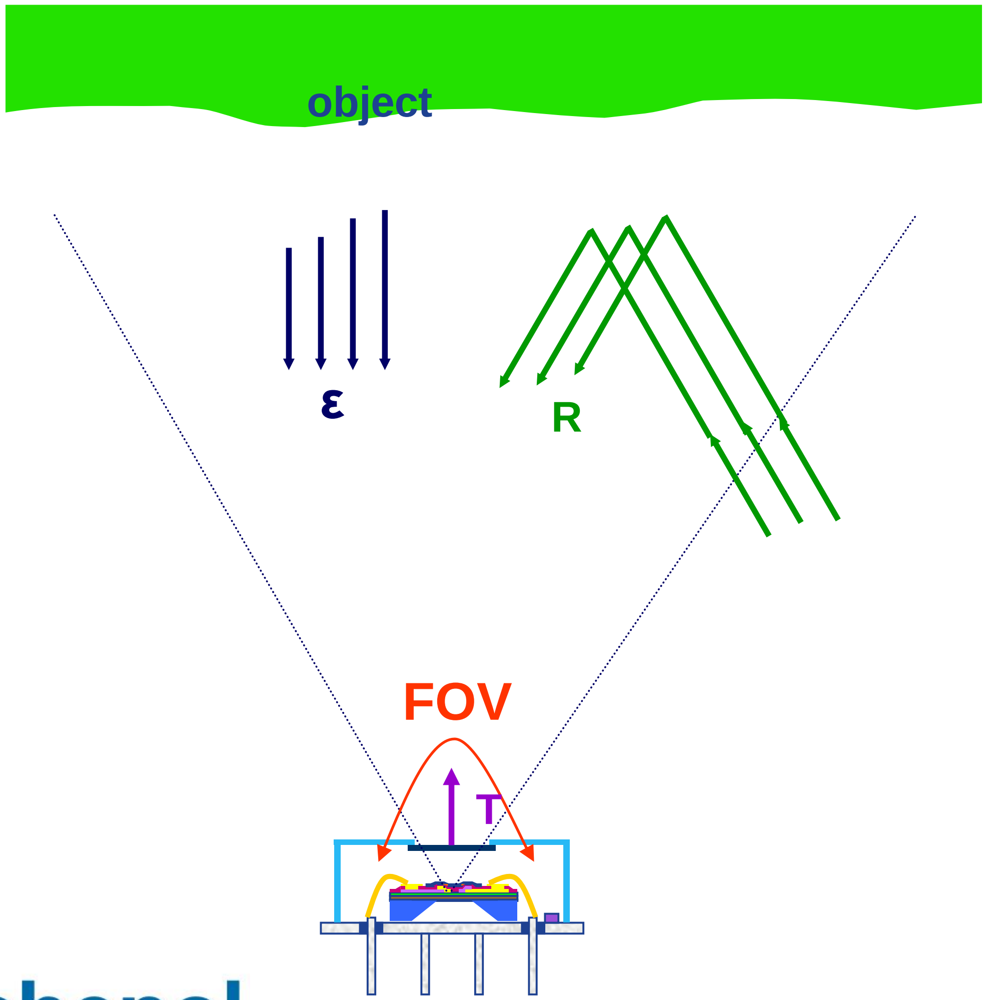
# Radiation. Reflection. Transmission.




$$\varepsilon + R + T = 1$$

ε = emissivity

R = Reflectance

T = Transmittance

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# Infrared Thermopile Sensors

## Approximate Emissivity Figures

| Material | Radiation | Material | Radiation |
|---|---|---|---|
| Paper | 0.92~0.94 | Aluminum (luster) | 0.095 |
| Plastic | 0.95 | Aluminum oxide | 0.26~0.42 |
| Ceramic | 0.90 | Copper (luster) | 0.05 |
| Water | 0.95~0.963 | Copper oxide | 0.78 |
| Human skin | 0.985 | Cast Iron (luster) | 0.21 |
| Paint (lusterless) | 0.95 | Nickel (luster) | 0.045 |
| Paint (luster) | 0.9 | Nickel oxide | 0.37 |
| Epoxy/Glass | 0.86 | Stainless steel | 0.16~0.44 |

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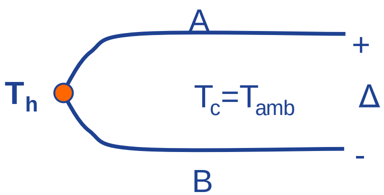
# Infrared Thermopile Sensors

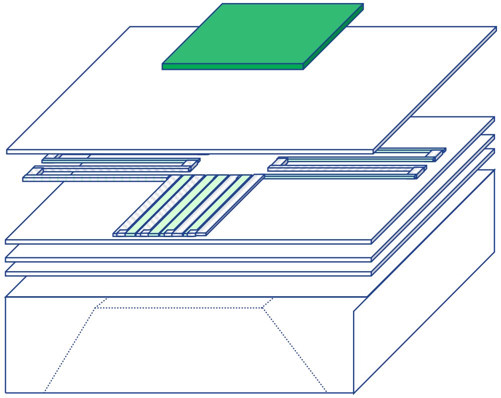
## Thermopile Construction

- Seebeck effect

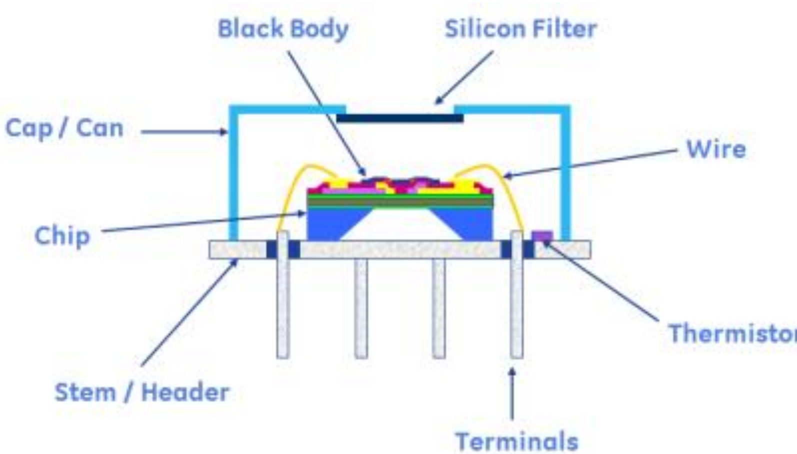



$$\Delta V = \alpha \, \Delta T = (\alpha_A - \alpha_B)(T_h - T_c)$$

- To increase the sensitivity (high Seebeck coefficient):
  - Higher $T_h$, lower T
  - More thermocouples
  - Heavier inert gas filling
  - Thin diaphragm with lower thermal conductance
  - Highly transmitted IR filter
  - High efficient IR absorber



*Sensing Mechanism*




*Thermopile Detector Packaging*

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# Infrared Thermopile Sensors

## What is a Thermopile?

- Serially-interconnected array of thermocouples
- Each thermocouple formed by the junction of two dissimilar materials
- Thermocouple array placed across hot and cold regions of structure
- Hot junctions thermally isolated from the cold junctions
- Cold junctions placed on silicon substrate for effective heat sinking
- Hot junctions formed over thin diaphragm that thermally isolates hot and cold junctions
- In hot regions, a black body absorbs the infrared energy, raising temperature according to the intensity of incident energy

# Infrared Thermopile Sensors
## Unique Features

Thermopile sensors have unique properties not offered by other detectors:

- Response to broad infrared spectrum
- No source of bias voltage or current needed
- Inherently stable response to DC radiation

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# Infrared Thermopile Sensors

## Features of Thermometrics Thermopile IR Sensors

### PRODUCT COMPARISON TABLE OF ZTP SERIES

| Part Number | Package type | Sensitivity(Vircal) @Tobj=40℃ | Thermopile resistance(kΩ) @Tamb=25℃ | Thermistor Resistance & B-Value @Tamb=25℃ | Filter transmittance range(um) | Field of View | Lead length (mm) | Window size (mm) | Main Application | Mass Production |
|---|---|---|---|---|---|---|---|---|---|---|
| ZTP-101T | TO-39(TO-5) | 1.0mV | 200 | 30kΩ_3811 | 6~13 | 50 degree | 6.7 | Dia 2.5 | Non-contact Temperature Measurement Thermometry, Medical, General Industrial, Occupancy Detection, HVAC, etc. | Yes |
| ZTP-115 | | 0.6mV | 50 | 10kΩ_3970 | 6~13 | 55 degree | 5 | Dia 2.5 | | |
| ZTP-135SR | TO-46(TO-18) | 1.3mV | 60 | 100kΩ_3960 | 6~13 | 85 degree | 13.5 | Dia 2.4 | | |

| Part Number | Sensor type | Main Application | Output type | Communication protocol | Pixel Q'ty | Range of Measuring Temperature(℃) | Ambient Temperature Range(℃) | Input supply voltage | Module Size (mm) | Mass production |
|---|---|---|---|---|---|---|---|---|---|---|
| ZTP-115M | Single module | General Industrial, Microwave Oven, Appliances, etc. | Analog | Voltage | Single | -40 ~ 145 | -20 ~ 120 | +5V | 17 X 33 | Yes |

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# Infrared Thermopile Sensors
## Thermopile Characteristics

$$V = S.(T_O^B - T_A^B)$$

$V$ = Output voltage from thermopile

$T_O$ = Object temperature in K

$T_A$ = Ambient temperature in K

$S$ = Sensitivity coefficient

$B$ = Coefficient (~4)

S and B are determined by measurement

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# Infrared Thermopile Sensors

## Temperature Compensation

- Output from thermopile varies with both ambient and object temperature
- Need to know the ambient temperature to calculate the object temperature
- Thermometrics standard thermopiles supplied with integrated thermistor for compensation
- Options include customer-specified thermistor or external temperature compensation (no internal thermistor)

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# Infrared Thermopile Sensors

## Various Filter Options

| Filter | Material | Transmission Range | Application |
|---|---|---|---|
| Standard | Silicon | 6~13um | Appliances, Microwave Oven<br>Medical, Ear Thermometer<br>Automotive, Tire Temperature<br>HVAC, Human Body Detection |
| F1 | Silicon | 8~14um | Occupancy Detection, Intruder alarms |
| F2 | Sapphire | 2~5um | Flame Detection, Analysis equipment |
| F3 | CaF2 | 1~10um | |
| NDIR | Silicon | 3.99±1% | reference |
| | | 4.65±1% | CO gas detection |
| | | 4.26±1% | $CO_2$ gas detection |
| | | 3.45±1% | HC gas detection |

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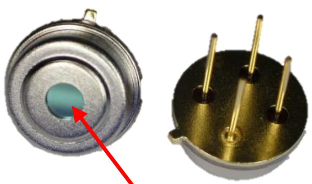
# Infrared Thermopile Sensors

## Standard ZTP Series

ZTP-101T

ZTP-115

ZTP-135SR



The ZTP series of IR thermopile sensors are used for non-contact surface temperature measurement. The product consist of thermo-elements, flat IR filter, a thermistor for temperature compensation in a hermetically-sealed TO package. There are also a variety of filters available to help maximize performance in specific applications.

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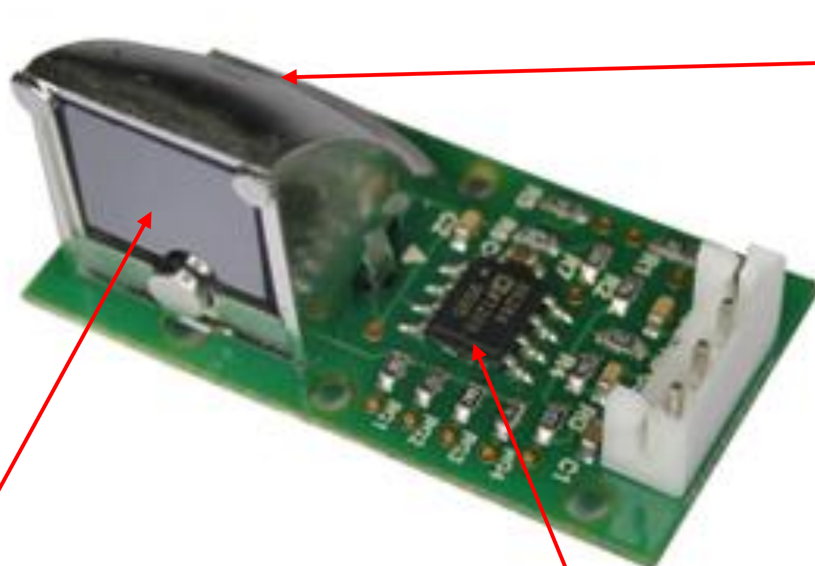
# Infrared Thermopile Modules
## Standard ZTP Series

ZTP-115M

The ZTP-115M is a single IR module. It consists of a thermopile, IR sensor, signal conditioning and voltage output.

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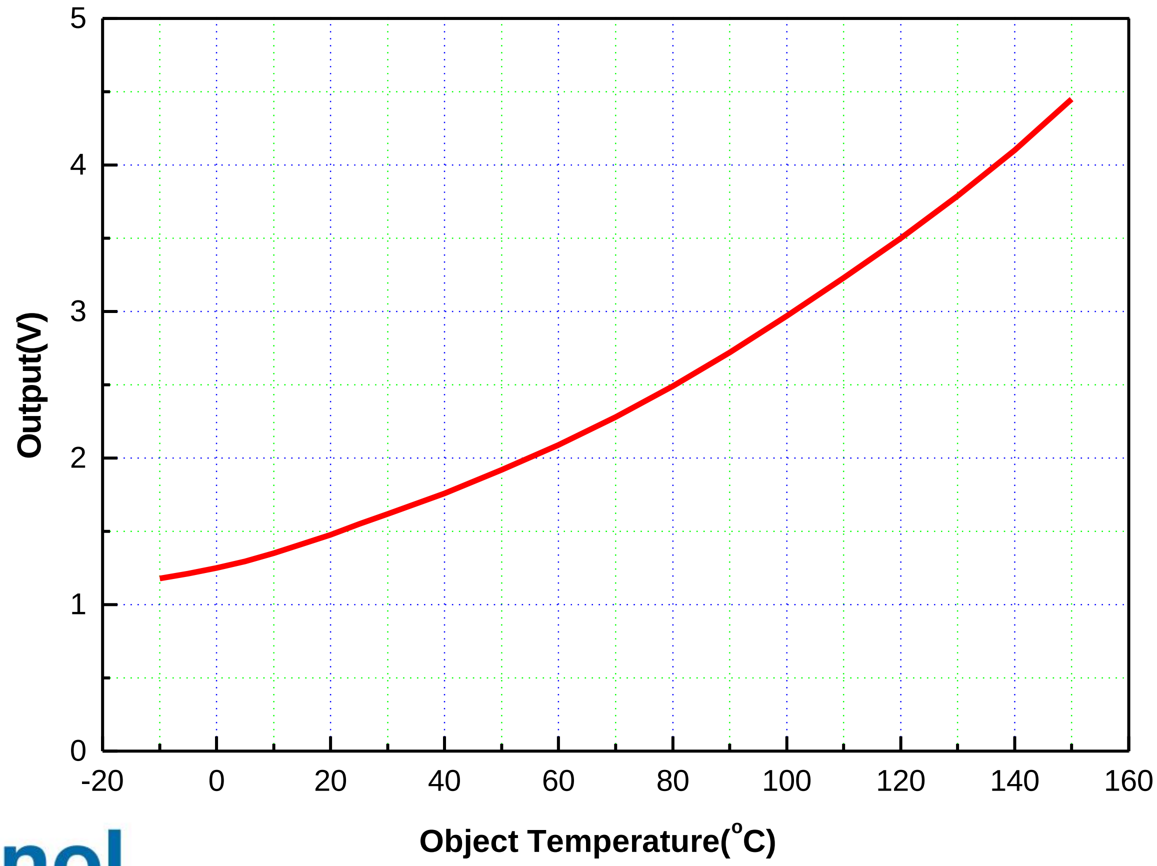
# Infrared Thermopile Modules

## ZTP-115M Signal Conditioning & Amplification

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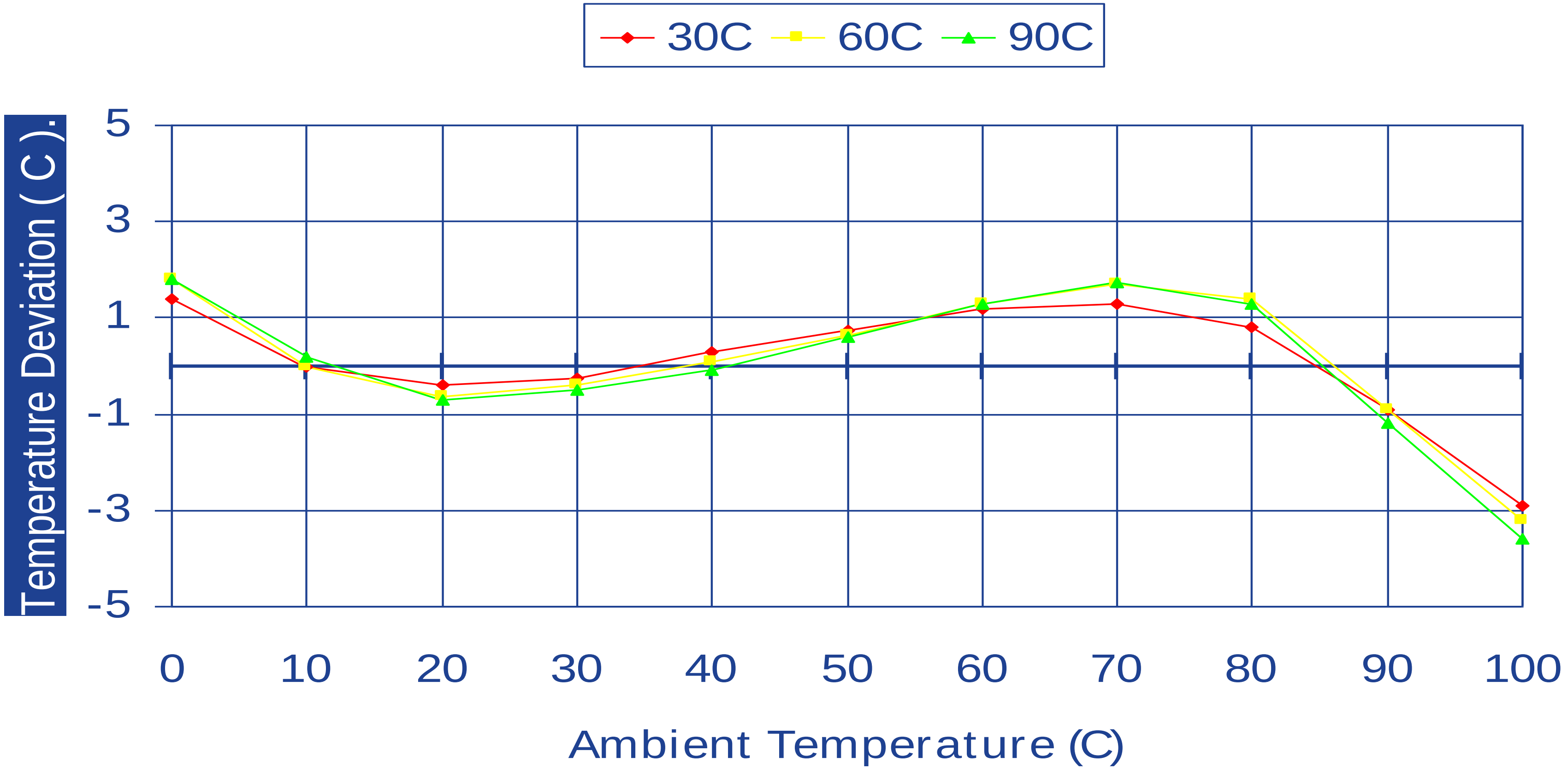
# Infrared Thermopile Modules

## ZTP-115M Compensated Output

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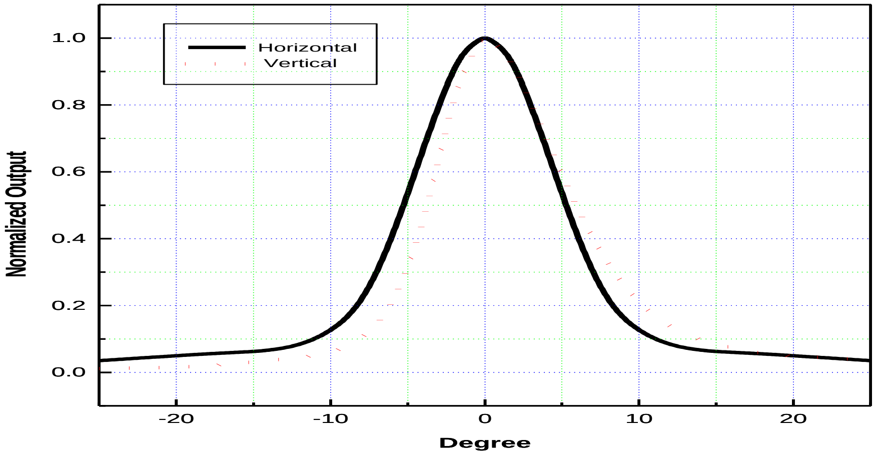
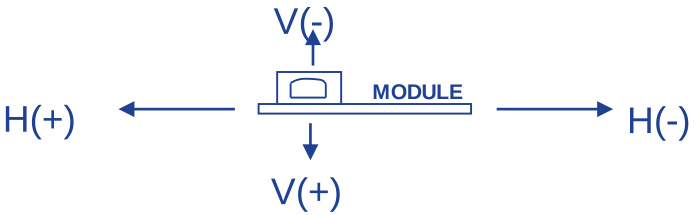
# Infrared Thermopile Modules

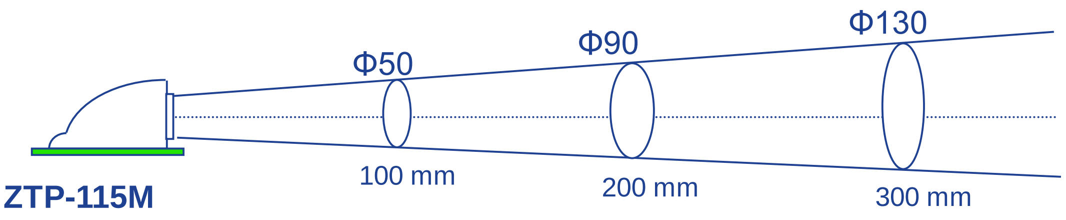
## ZTP-115M Field of View




H(+/-) : Horizontal Direction
V(+/-) : Vertical Direction

(3) Spot Size of Normalized Output(above 10%)

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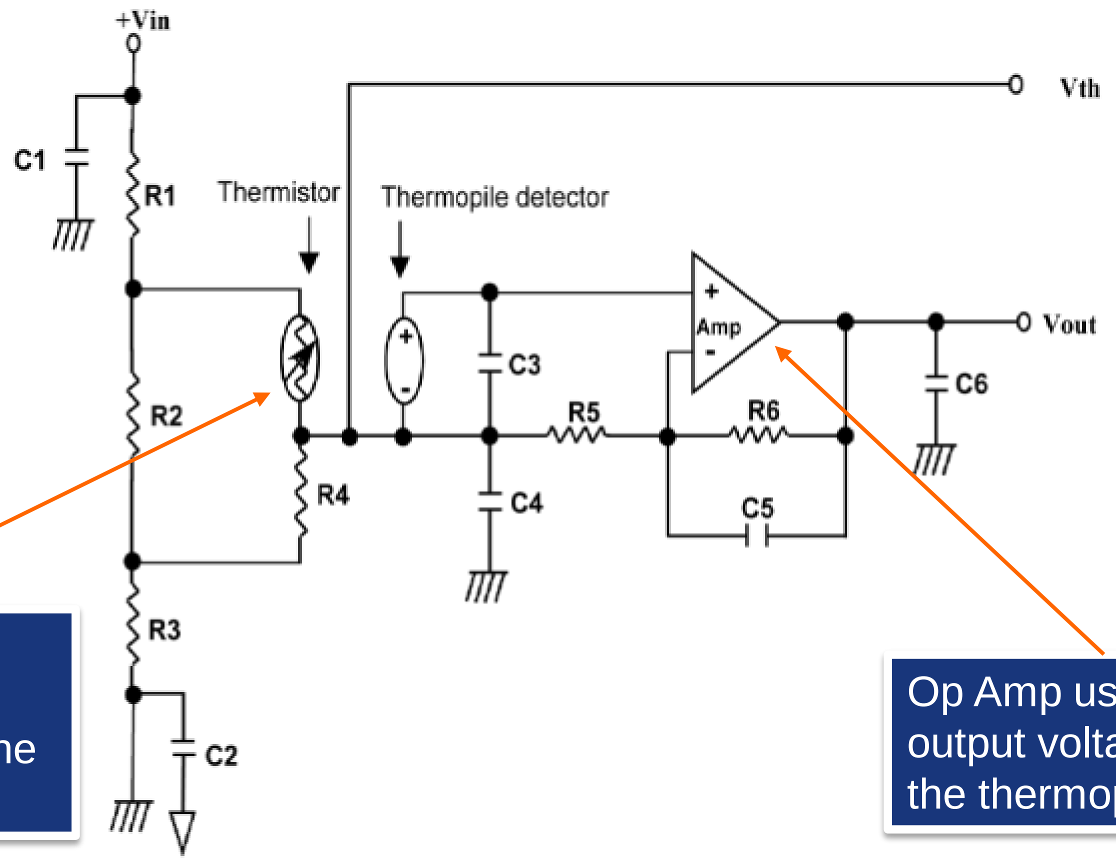
# Infrared Thermopile Sensors

## Example Interface Circuit




NTC Thermistor used for compensation of the ambient factors.

Op Amp used to amplify the output voltage signal from the thermopile

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# Infrared Thermopile Sensors

## Typical Applications

- Ear, Forehead Thermometry
- Non-contact Temperature Measurement Thermometry
- Microwave Ovens
- Induction Heater Cookers
- Air Conditioners
- Occupancy Detection
- Lighting
- Underfloor Heating Control
- HVAC / Automotive






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