Preamplifier for Micromachined Thermopile Infrared Detector

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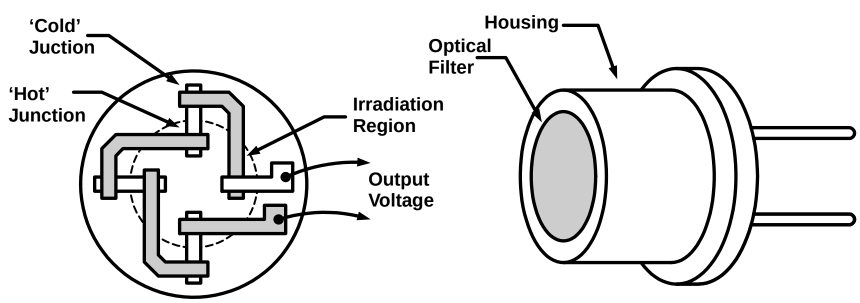
Micromachined thermopiles are a new and increasingly popular technology used for detecting longwave infrared radiation (≈10µm). Typical applications include non-contact thermometers, security sensors, automotive occupancy detectors and non-invasive medical thermometers. Because of the large thermal mass of traditional wire-type thermocouples, they are difficult to use as sensitive infrared radiation detectors. Micromachined thermopiles, being very small and having low thermal mass, can be measurably heated by infrared radiation emitted by objects at common environmental temperatures (0°C-50°C). Additionally, low thermal mass contributes to fast (< 100ms) response times.

A thermopile is an array of dissimilar metal or semiconductor junctions, each of which produce a small voltage when a temperature gradient is applied. One way of visualizing a thermopile is as a series-connected array of thermocouples, as shown in Figure 1. The thermocouple junctions are placed so that junctions of one sense (material 'A' to material 'B') are kept at different temperature than those of the opposite 'sense' (material 'B' to material 'A'). When all junctions are at the same temperature, zero net voltage is produced as any voltages developed are cancelled out by those of opposing junctions. To get a non-zero output voltage requires that the junctions of one sense are at a different temperature than those of the opposite sense. In an infrared detector, this is often accomplished by placing one set of junctions in an area that will receive incoming radiation while placing the others in a place that will not see any radiation, and may also be heat-sinked to the housing. By doing this, any incoming radiation will heat the 'hot' junctions more so than the 'cold' junctions. This causes a different voltage to appear across the hot junctions than across the cold ones. The total sum of the voltage appearing across all the junctions will therefore be non-zero.

Figure 1. Simplified Infrared Thermopile and Typical Packaging



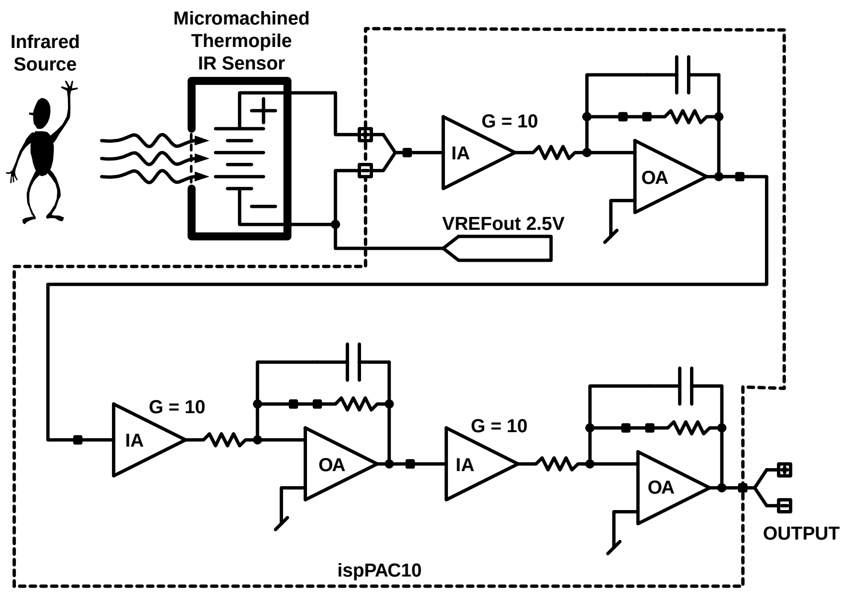
Additionally, since one employs a thermopile to detect long-wave infrared radiation, an optical filter is often included in the packaged assembly to exclude short wave infrared and visible light.

Although hundreds of individual junctions may be employed in a micromachined thermopile, the total output voltage may still be measured in the tens or hundreds of microvolts. Detecting small signals such as these requires a low-offset, high-gain amplifier. Figure 2 shows how an ispPAC®10 can be used as a differential 1000X preamplifier for this application.

The ispPAC10 offers several advantages in this application deriving from its differential signal processing architecture. Because it provides differential inputs, the ispPAC10 is capable of detecting very small signals while still operating from a single +5V power supply. Additionally differential signal processing reduces the amount of electrical noise picked up between the transducer and the amplifier.

The ispPAC10's programmability also offers several advantages. Different preamplifier gains can be programmed into devices after they have been attached to a Printed Circuit Board (PCB), allowing for the same preamplifier to be used with several different types of thermopiles. With a few minor modifications in the preamplifier, requiring no

Figure 2. Using an ispPAC10 as a 1000X Preamp for a Thermopile Infrared Detector



PCB redesign, precision (+/-1%) gain trims can also be implemented for high-accuracy infrared sensing applications. Additionally, when ispPAC devices are used as high-gain amplifiers, it is easy to also use them to implement filters with corner frequencies down to a few hundred Hz. Detailed information on implementing low-frequency filters with ispPAC can be found in application note AN6020 “Expanding Frequency and Gain Ranges of the ispPAC10 and ispPAC20.”

Technical Support Assistance

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