WINTRONICS, INC.

CHOPPED RADIATION METHOD TECHNOTE

WHAT IS THE CHOPPED RADIATION METHOD ?

In describing the working principle of infrared radiation pyrometers, the term "chopped radiation" is used to characterize the mechanical or optical modulation of radiation, primarily thermal infrared radiation, intercepted by the infrared detector. In general, this is accomplished by an optical chopper, basically mechanical blades driven by a suitable electromagnetic device, such as an electric motor, which periodically interrupts the incident radiation from the measured target to the detector. During each interruption the detector is exposed to a reference radiation, generally an internal blackbody reference source having a defined temperature.

WHY IS THE CHOPPED RADIATION METHOD USED ?

to Operate Pyroelectric Detectors

High quality, high performance infrared detectors of the pyroelectric type must be operated in the chopped radiation method, because they respond to radiation differences only, not to absolute radiation intensities. Pyroelectrics are the best uncooled detectors available, in terms of detectivity, fast response, reliability and stability.

to Eliminate Thermal Drift

Detectors in all infrared pyrometers intercept infrared radiation emitted by the measured target and, at the same time, radiation emitted by the detector enclosure. For unchopped pyrometers, the radiation from the detector enclosure, which corresponds to the pyrometer's housing temperature, gives rise to a bias on the output signal of the detector and subsequently to thermal drift, whenever the housing temperature changes.

Also, for unchopped pyrometers measuring low temperatures at or below the ambient or when focusing on small targets, the bias exceeds the measured signal by two orders of magnitude. In a typical design with a 20 degree detector field-of-view the radiation bias is approximately 100 times higher than the measured signal from a target at ambient temperature.

Correct compensation of this bias for a specified accuracy of 1°F would require a stabilization of the housing temperature for better than 1°F/100 = 0.01°F, a virtually impossible specification for any affordable industrial/commercial unchopped pyrometer.

The chopped radiation method eliminates this problem completely. A pyrometer with this method evaluates two subsequent signals:

$$S_1 = S_{target} + Bias$$

$$S_2 = S_{reference} + Bias$$

$$S_{delta} = S_l - S_2 = S_{target} - S_{reference}$$

During the short chopping cycles, which are normally in the millisecond range, the temperature of the pyrometer's housing and the bias do not change. The bias is thus eliminated completely and substituted by the reference signal, which can be easily measured or controlled within the specified reference accuracy of < 1°F over the permissible ambient temperature range.

To Reduce Signal Noise

The chopped radiation method automatically provides a modulated signal with a precisely defined frequency. Such a signal lends itself to a narrow band selective filtering by phase sensitive demodulation or digital signal processing with unsurpassed noise suppression and signal stability.

CHOPPED RADIATION METHOD BENEFITS

Virtually no thermal drift

Excellent dynamic compensation of thermal shock

Unequaled noise filtering

High temperature resolution

High spatial resolution (small target detection) Fast response

Long-term stability

DESIGN COMMENTS

It is often argued that the chopped radiation method has its weak link in the optical chopper, as it tends to make pyrometers more expensive and unreliable. This may have been or possibly still is the case for obsolete or badly designed pyrometers. Of course, an optical chopper always adds to the manufacturing costs, but it is generally less than 5% in comparison to the total cost of the pyrometer.

Today, reliability and life time of advanced mechanical choppers are fully consistent with overall system performances. MTBF of the latest Heimann chopper, manufactured since 1986, is specified at 72,000 hours (9 years) of continuous operation under specified environmental operating conditions.