

# Dual-Band MWIR/LWIR Radiometer for Absolute Temperature Measurements

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## ABSTRACT

A Dual-band Radiometer (DBR) has been developed to accurately measure temperature at long ranges. Key to the DBR is a dual-band, quantum well infrared photodetector (QWIP) focal plane array (FPA) that integrates within each pixel both mid-wavelength infrared (MWIR) and long-wavelength infrared (LWIR) spectral sensitivity. A vertically-integrated, two-color FPA eliminates with inter-band optical distortions, temperature-induced alignment errors, and improves radiometric measurement accuracy.

The DBR system is sensitive to human targets, yet minimally sensitive to atmospheric conditions, enabling accuracy over the widest possible range of global conditions by using Two-color Imaging Radiometry (TCIR) to establish a target's absolute temperature within  $\pm 1^\circ\text{C}$ . The benefits of TCIR for greybody measurements are absolute atmospheric transmission values are not required and uncorrelated shifts in the spectral band transmission cause minimal error.

The system is packaged with an eye-safe laser rangefinder, GPS, and weather station suite, which provides real-time atmospheric measurements. These measurements are input to the USAF MOSART predictive atmospheric codes, which are used for real-time field calibration of the data. The magnification necessary to resolve facial features from 200 m to 750 m range requires a custom designed 6" diameter,  $\phi 7$  telescope with temperature-stable optical alignment over a wide range of operational temperatures.

**Keywords:** Radiometer, Two-Color Imaging Radiometry, TCIR, quantum well infrared photodetector, QWIP, thermography, infrared, Active Denial System, ADS, MOSART

## 1. INTRODUCTION

Accurate long-range temperature measurements are useful for a number of important applications. As example, in countless battlefield and emergence situations, such as those requiring triage, vital physiological parameters, such as skin temperature, must be measured when direct contact is not possible (Figure 1). The requirement driving the design and development is an accurate, long range, imaging radiometer capable of measuring the temperature of human faces within  $\pm 1^\circ\text{C}$  at distances up to 750 m.

One application driving such requirements is the joint service Active Denial System (ADS). The ADS program is a breakthrough non-lethal technology that uses millimeter-wave electromagnetic energy to stop, deter, and turn back an advancing adversary from relatively long range. It is expected to save countless lives by providing a way to stop individuals without causing injury, before a deadly confrontation develops. Non-lethal technologies can be used for protection of Defense resources, peacekeeping, humanitarian missions, and other situations in which the use of lethal force is undesirable. The system is intended to protect military personnel against small-arms fire. The technology was developed by the Air Force Research Laboratory and the Department of Defense's Joint Non-lethal Weapons Directorate.



Figure 1: 30 meter LWIR QWIP images with dual-isothermal thresholding (green  $\Delta 1^\circ\text{C}$  above  $29^\circ\text{C}$  and yellow  $\Delta 3^\circ\text{C}$  above  $27^\circ\text{C}$ ).

# Dual Band Mwir Lwir Radiometer For Absolute Temperature

**R. V. Dunkle**



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