INFRARED MIRRORED FORE-OPTIC RADIOMETER MODEL TIR-570

BULLETIN TIR-570

General Description

The Model TIR-570 Total Infrared Radiometer represents the state-of-the-art for making precise field measurements of downwelling broadband atmospheric infrared irradiance. The TIR-570 uses a advanced chopped pyroelectric detector and precision interference filter integrated with a self-contained black body source to measure spectral irradiance from 4 to 30µm. Global climate change researchers now have a tool for routine high accuracy field atmospheric IR measurements.

The system consists of two basic components: a Detector Assembly and an electronics enclosure with top-mounted spherical mirror. The Detector Assembly consists of a black body radiation calibration source, a stepper motor-driven rotating chopper and pyroelectric detector mounted in a common housing. The electronics enclosure contains the microprocessor-controlled data acquisition and digital lock-in amplifier circuitry.

The TIR-570's broadband IR measurement complements the total solar irradiance measured by a pyranometer such as the Model TSP-700. A unique, internal black body radiation source supports null detection, and is the key to the system's excellent long-term calibration stability. It overcomes visible signal contamination issues that has historically plagued passive infrared radiometers.

Features

- State-of-the-art chopped pyroelectric wide band detector for highest absolute accuracy
- Fully automated atmospheric infrared solution for remote operation — integrated data acquisition system processes sensor data
- Internal IR blackbody source provides continuous null detection
- Synchronous detection uses digital lock-in amplifier to eliminate DC drift
- Durable mechanical and electronic design of sensor head prevents errors due to local environmental factors

Applications

- Global warming and global climate change research
- Validation of global circulation models (GCMs)
- Runway icing and severe storm research
- Replacement of older passive IR radiometers

TIR-570 System.

Principle of Operation

Unlike visible pyranometers that absorb incident radiation, IR radiometers instead radiate out to a cooler object, for example, the base of clouds or outer space. Because the atmosphere has a transparent window from 8-14 µm, data are highly dependent on the presence or absence of clouds. The TIR-570 Detector Assembly employs a precision rotating chopper wheel that makes alternating exposures of an internal temperature-regulated black body and the sky itself. The emitting surface temperature of the black body is closed loop-controlled to be identical to the signal the pyroelectric detector produces when it is exposed to the sky. The final signal is retrieved via a synchronous demodulation system. Synchronous detection is implemented in the digital domain via a microprocessor to eliminate both multiplication errors and offsets that are unavoidable via conventional analog lock-in amplifiers.

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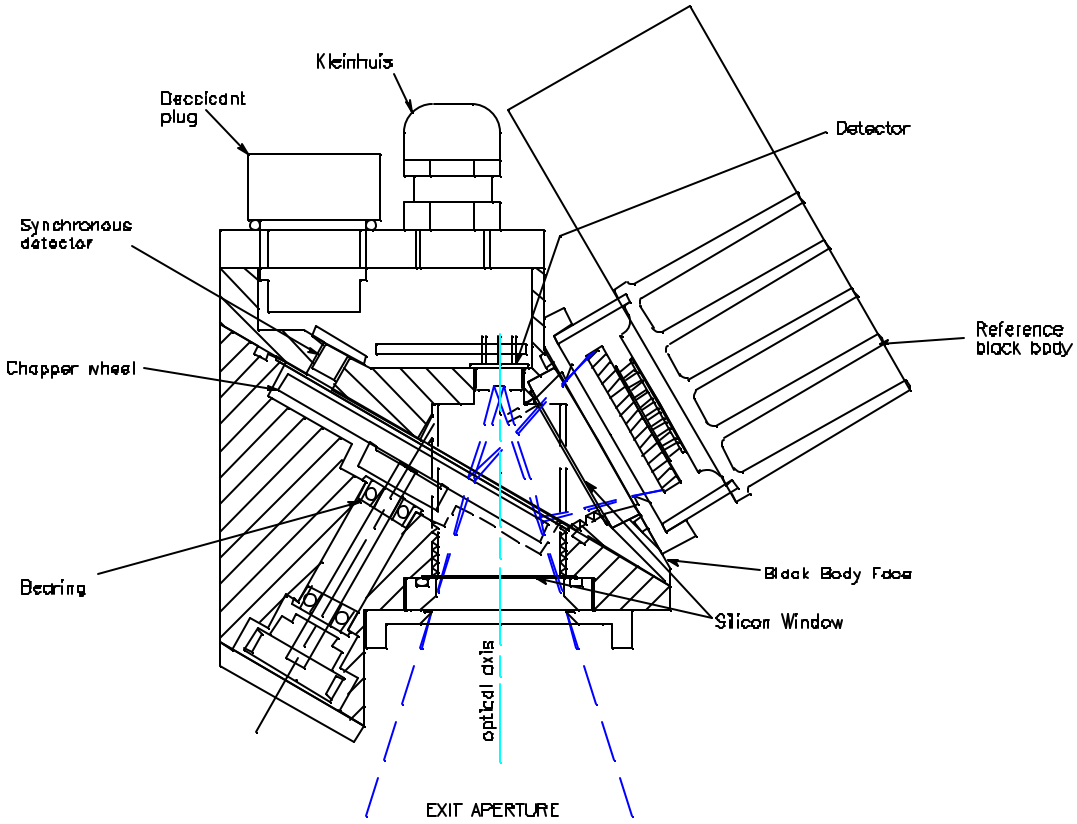

Detector Assembly Side Detail

A cross section side detail of the Detector Assembly is shown above. The narrow ±17.4° field-of-view is expanded by a convex hemispherical mirror which reflects IR photons from the sky through a precision interference filter positioned in front of the pyroelectic detector. The mirror fore optic can be cleaned, providing good cosine response and excellent long-term stability. The visible optical filter blocks wavelengths shorter than 3µm from the solar spectrum, and only the IR portion is detected by a wideband pyroelectric detector. A rotating chopper wheel provides AC optical signal excitation required by the pyroelectric detector, (which only reacts to changes in light and not a steady state flux.) By employing null-detection, system accuracy depends only on the stability of the thermoelectrically-controlled internal black body source and is therefore independent of detector sensitivity. This helps eliminate problems caused by ambient temperature-induced amplifier gain drift and other long-term sensitivity changes.

The operation of the instrument is controlled by a dedicated embedded microprocessor control system. The on-board CPU that 1) controls the acquisition, processing and storage of sensor data for the system, 2) performs the required ephemeris calculations, 3) permits simultaneous data telemetry, and 4) controls the optional stepper motor which positions the shadow disk. The integral YESDAS-2 data acquisition system can acquire other co-located meteorological sensor data. The black body calibrator, pyroelectric detector, interference filters, and sensitive electronic components are all held inside the desiccated Detector Assembly, ensuring long life and elimination of ambient temperature-induced errors.

Factory-Supplied Optical Calibrations

Traditional broadband IR radiometers (e.g. pyrgeometers) tend to require fairly sophisticated data handling and post-processing to accommodate dome and/or case temperature corrections when applying engineering units. The TIR-570 breaks this trend by producing fully calibrated measurements.

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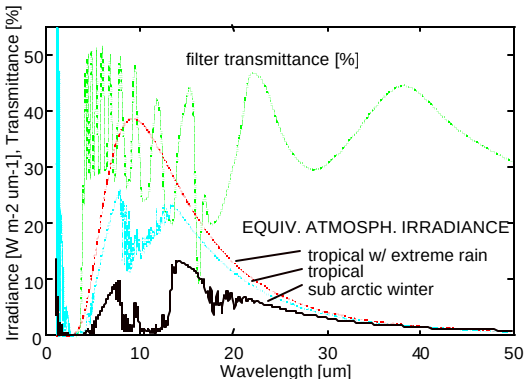
The usefulness of any radiometric instrument depends critically on the accuracy and long-term stability of its calibration. YES operates an advanced optical laboratory to completely characterize the performance of each instrument. TIR-570's are typically recalibrated yearly. If you are interested in our IR calibration capabilities or would like to discuss your specific calibration requirements, please contact us.



Typical Atmospheric IR spectrum

Spectral Response

To block the visible signal from being detected, a precision visible cut-off filter is used. The interference filters used are of the highest quality available and result in an instrument with exceptional ruggedness, long-term stability of calibration, and excellent unit-to-unit repeatability of response. A laboratory-derived spectral response is supplied with each system.

Absolute Response

The absolute response of each TIR-570 instrument is measured using a custom, wide aperture IR calibrator initially developed at the World Radiation Center in Davos, Switzerland. Before the chamber was assembled, glass-encapsulated thermistors were calibrated against a NIST-traceable SPRT in a Hart Scientific bath. This chamber was also cross checked against a NIST-traceable Electro-optical Industries, Inc. infrared spectral irradiance standard.

Data Format

The TIR-570 can provide data either as calibrated temperatures or as calibrated spectral irradiance units. Data are available as analog outputs and via YESDAS Manager's web browser interface. A second diagnostic serial port provides real time controller status for QC purposes.

Installation Requirements

The TIR-570 instrument is easy to install. The instrument should be installed on a level, stable surface and secured via bolt holes in the electronics enclosure base. Connect to AC power, and run a serial cable to a MS-Windows 9X/NT PC. Connect a deep cycle marine/RV 12V DC standby battery (the system can optionally be configured to permanently operate from a DC battery system.) We recommend that you furnish a ground rod to ensure a discharge path for lighting protection.

Packaging

The Detector Assembly is fabricated from anodized aluminum; hardware is stainless steel and connectors are potted and weatherproof. The Electronics Enclosure (housing the power supply, data controller board and ancillary electronics) is a metal NEMA-4X box. The power supply is a medical-grade, linear type, with a dual bobbin transformer for maximum power line transient signal and noise rejection.

Instrument Development and History

The TIR-570 instrument was developed under an R&D program funded by the U.S. Department of Energy, and was designed to be both rugged and automated to support long-term field programs. The study of the global energy balance between the earth and the atmosphere, for programs such as the ARM program, required high accuracy long-term broadband IR data. Existing pyrgeometers simply could not provide the accuracy required.

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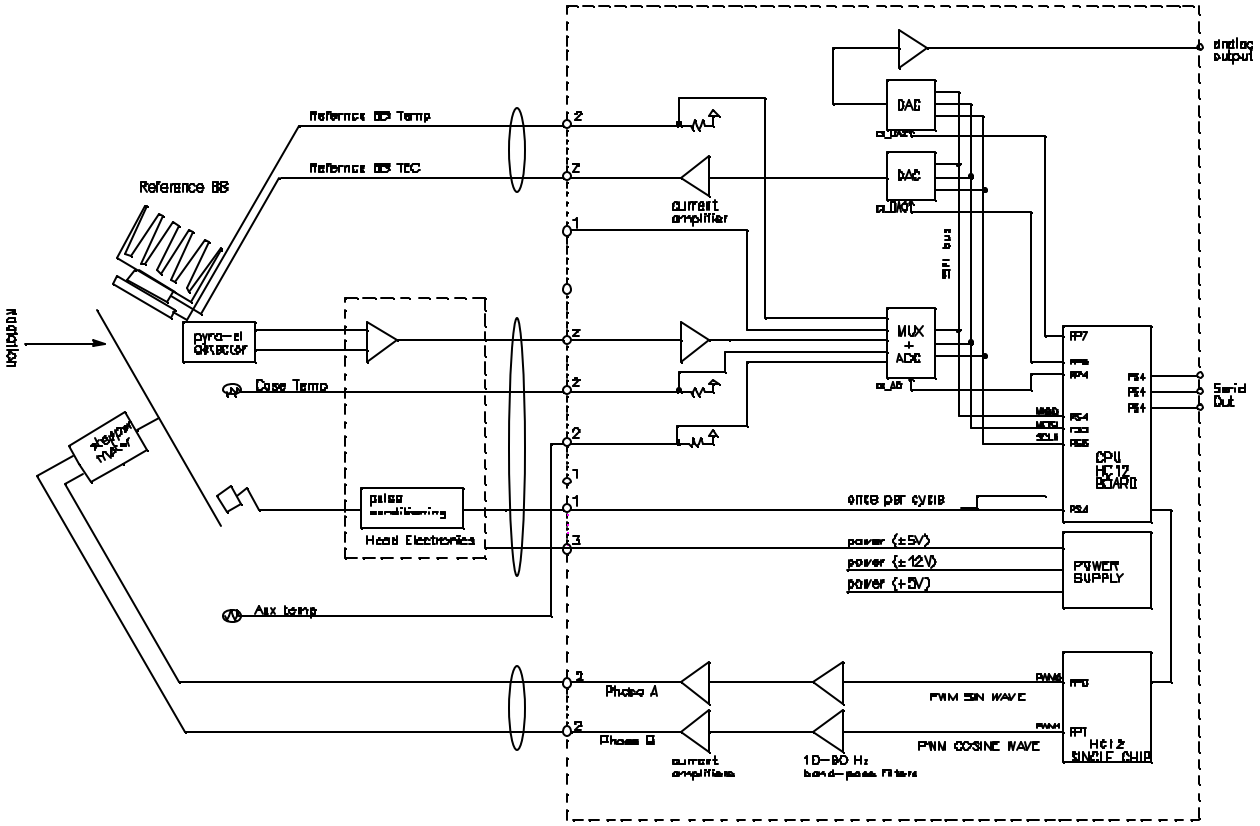
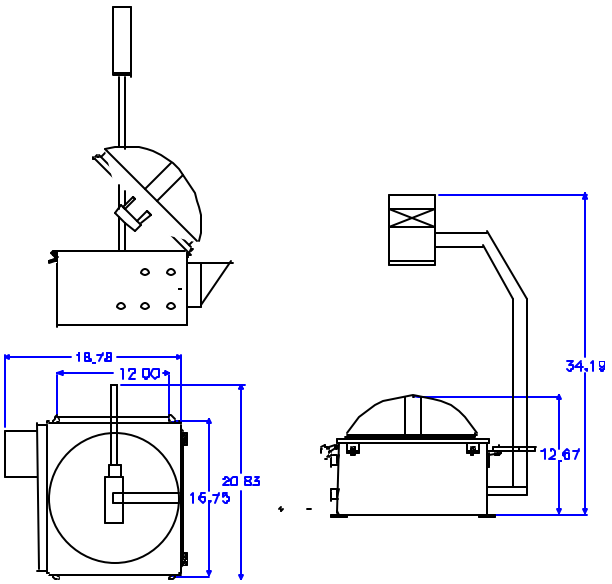


System Electronics Block Diagram



Mechanical Interface

Infrared Radiometer offers a lower cost solution**.** The TIR-550 meets the specifications for WMO stations. Advanced technology YES radiometers support scientific research in academic, government and industrial programs across the world.

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Also Available

For more cost-sensitive IR atmospheric radiation measurement applications that do not require the highest accuracy, the YES Model TIR-550 Total

Specifications

Spectral Response:	4-30 µm
Time Response:	<10 seconds to 1/e
Radiometric Accuracy:	±1 Wm^{-2} over the 0 to 35°C range in a black body calibrator; total system errors including spectral and cosine are estimated to <2%
Cosine Response:	Better than 5% for 0-70° zenith angle
Temperature Range:	-40°C to +50°C
Power Requirement:	115/230 Vac, 50/60 Hz or 12V dc. 18 Watts (max). Optional AC heaters require 200W
Sampling Rate:	12 bit ADC, Up to 4 samples per second
Communications :	2 RS-232C serial ports
Weight/Size:	Approx. 35 lbs. (16 kg); dimensions: base is 16" x 30" (41cm x 76cm); height is 28" (71cm)

Note: Specifications subject to change without notice.

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