Measurement & Analytics / Measurement made easy

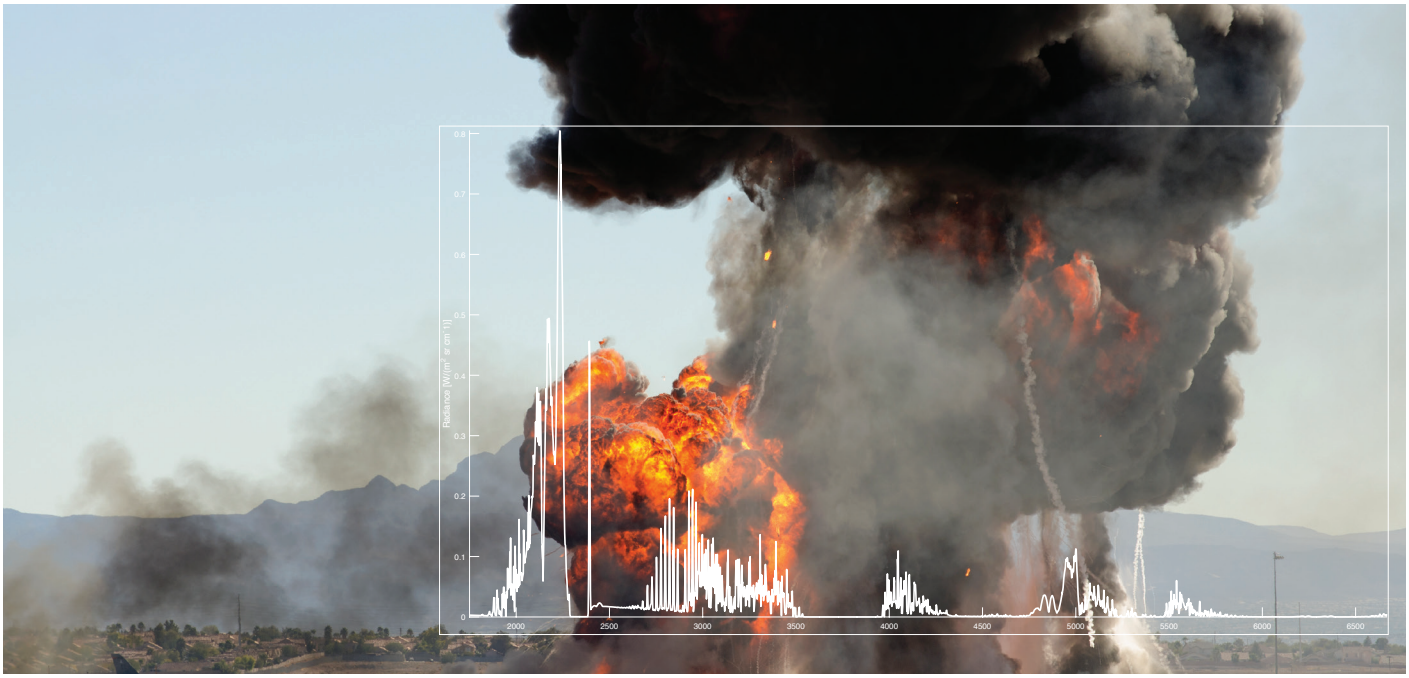
Hyperspectral MR-series FTIR Spectroradiometers
Radiometric Accuracy for Infrared Signature Measurements

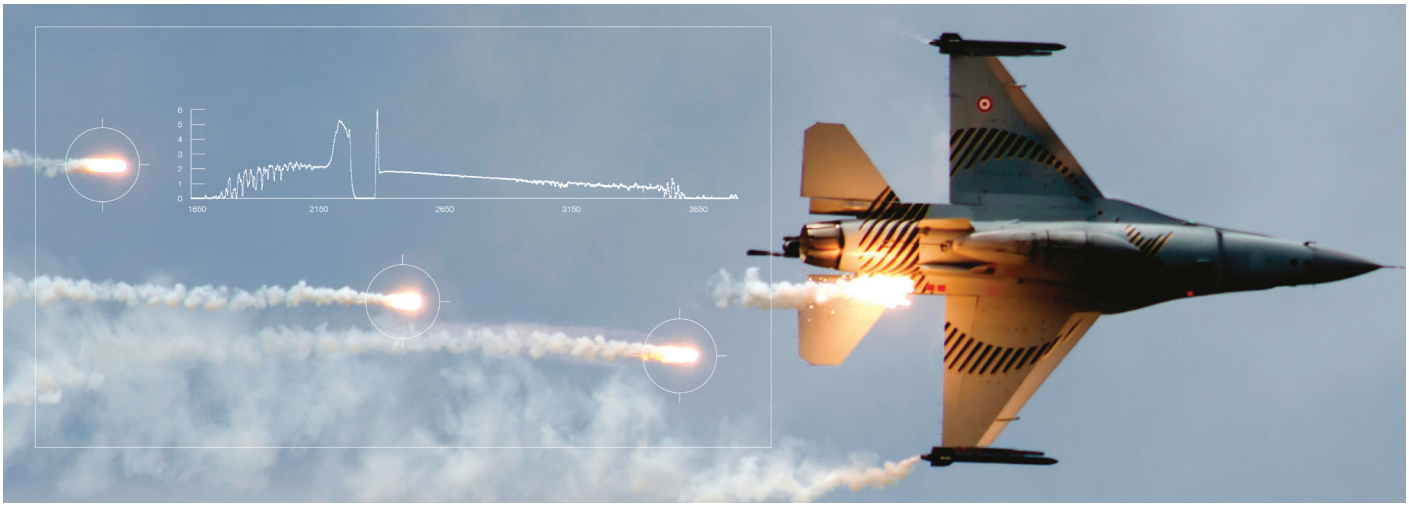
Power and productivity
for a better world™

The most accurate solution to capture the elusive

MR Series FT-IR spectroradiometers

The MR Series are the leading field infrared spectroradiometers among the defense research organizations both in terms of performance and reliability, with undisputed market dominance since its introduction in 1989. The MR Series of spectroradiometers have earned a high reputation based on exceptionally high spectral resolution and radiometric reproducibility, wavelength accuracy, and sensitivity. The MR Series spectroradiometers are build from a Michelson interferometer configured with dual output ports able to simultaneously cover the LWIR to the SWIR spectral range. The radiometric configuration of the MR spectroradiometer ensures a stability of response under various illumination scenarios. The Fourier Transform Infrared Spectroscopy (FTIR) technology allows high spectral resolution up to 9000 spectral bands per spectrum and rapid scanning measurement rate above 100 Hz.





Wide range of applications

MR series Spectroradiometers have specifically been conceived for the following applications.

- Characterization of thermal emission signatures of targets such as: airplanes, missiles, rockets, helicopters, drones, ground vehicles, ships, etc.
- Development, analysis and improvement of IR decoy emission spectra and advanced counter-measure systems
- Spectral characterization of camouflage systems
- Classification of fugitive emissions for developing infrared signature databases;
- Classification of battlespace detonations and emissions, including bomb-hit detonation, muzzle flash, and missile launches
- Remote sensing of battlefield conditions for developing various deployable reconnaissance solutions

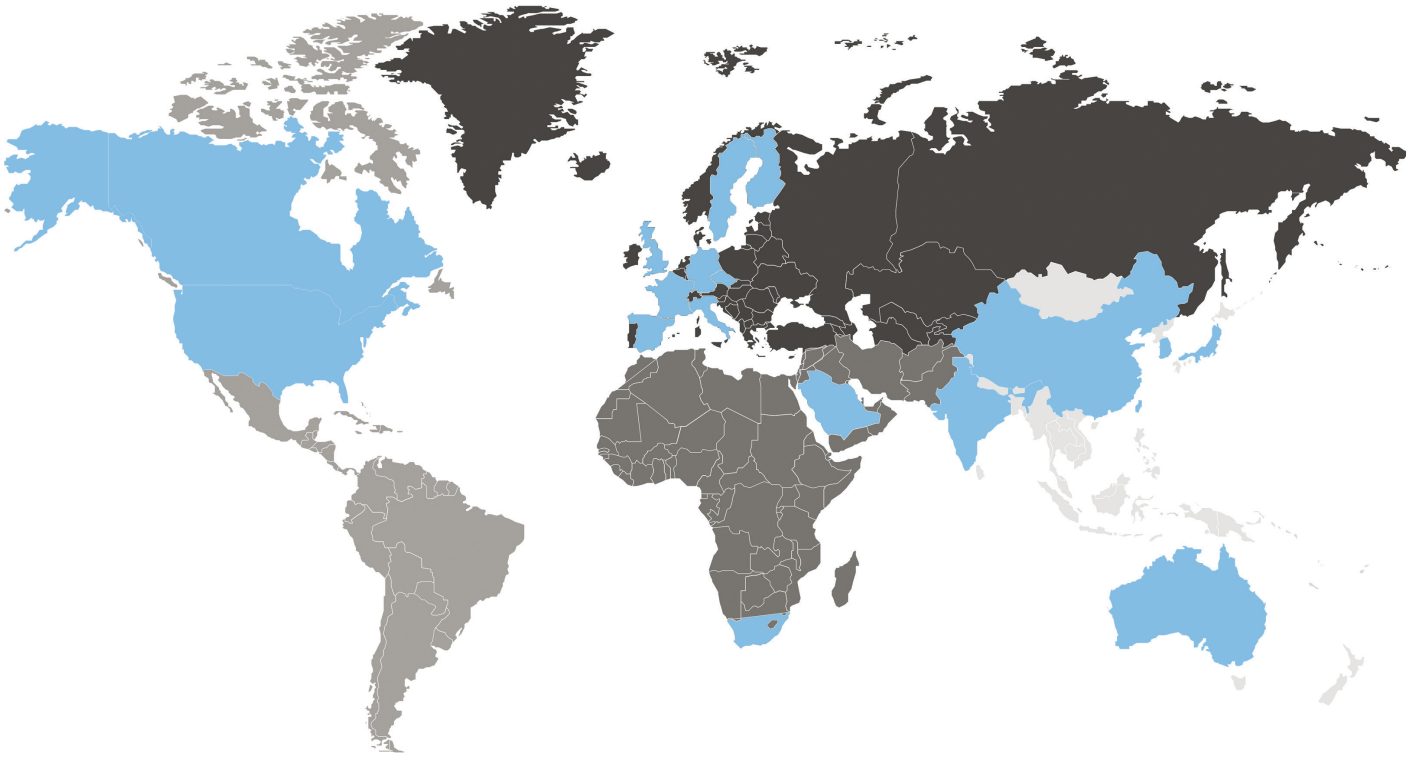
Infrared spectral signature for countermeasure

The ABB MR Series spectroradiometers are the preferred solution to infrared spectral characterization applications within the defense research organizations.

Most military research teams in the world are relying on the MR spectroradiometer to measure the infrared spectral signature of a multitude of different type of targets and infrared emitted events.

The high reputation achieved by the MR Series spectroradiometers among the defense research organizations was gained by the performance superiority of its FTIR technology combined with reliability, operation simplicity and high radiometric accuracy of spectral measurements.

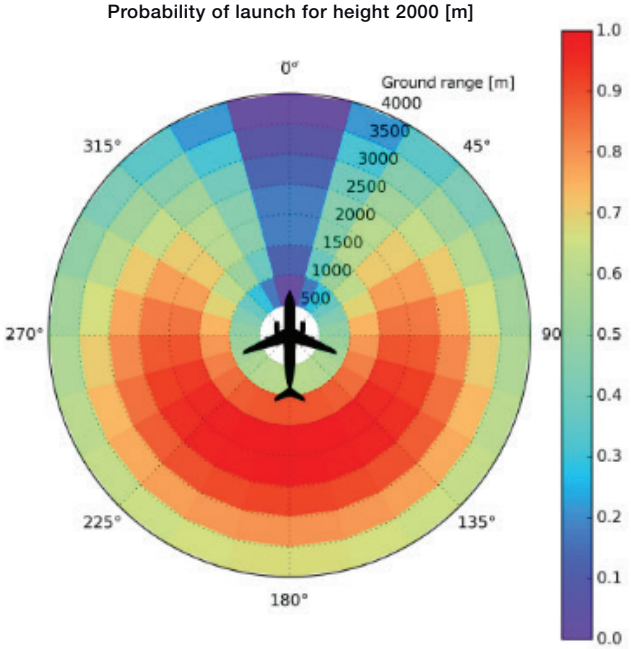
MR Series FTIR of Spectroradiometers



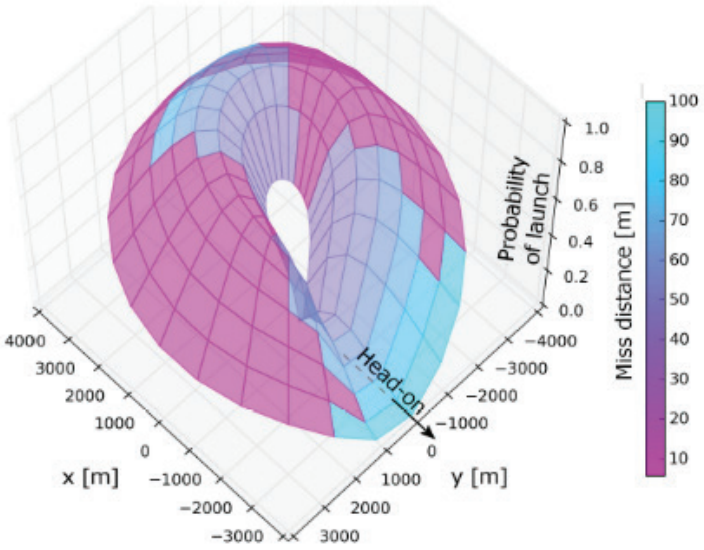
MR series over the world

Defense research organizations around the world rely on the MR series spectroradiometer to fill their needs in accurate measurements of emitted spectral signature. The following figure represents over 20 countries where the MR spectroradiometer is being routinely operated.

Australia
Canada
China
England
Finland
France
Germany
India
Israel
Italy
Japan
Holland
Republic of Czechoslovakia
South Africa
South Korea
Saudi Arabia
Singapore
Spain
Sweden
Taiwan
Turkey
United states of America



(a) Launch probability: aircraft at 2000 m.



(b) Combined miss distance and launch probability.

Aircraft vulnerability assessment

Radiometric accuracy, a parameter for infrared counter measure efficiency

Radiometric errors in the characterization of a threat, the vulnerability assessment of a military platform, or the counter measure efficiency of an IR counter measure can lead to safety weakness. For instance a wrong assessment of an aircraft stealth infrared radiation could lead to the wrong assessment of launch probability assessment and wrong countermeasure actions.

As the nature of Infrared Countermeasure (IRCM) systems and Infrared Counter-Countermeasure (IRCCM) systems is rapidly evolving and are continuously improving, higher precision is required to characterize infrared signatures. The IRCM and IRCCM systems improvements rely mainly on the target infrared signal contrast within its background and the infrared signal phenomenology of the target versus the IRCM.

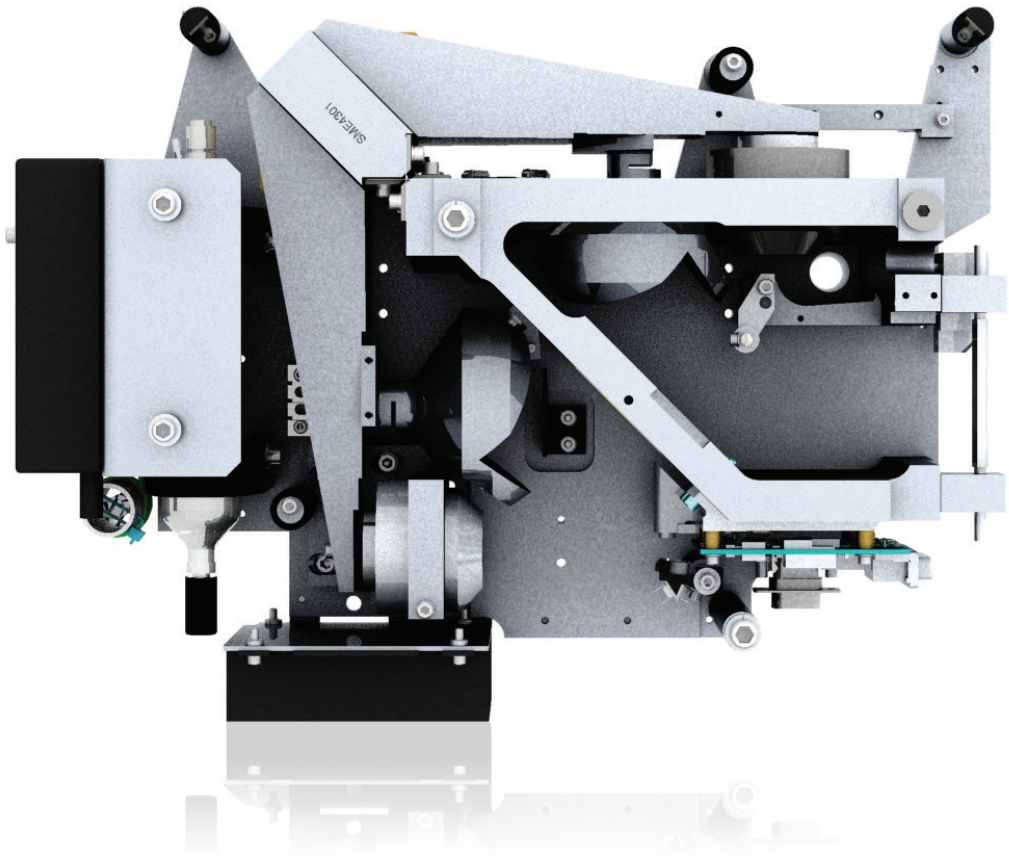
Accurate knowledge of infrared spectral signature phenomenology is crucial to further improve IRCM / IRCCM systems. Therefore, precise quantification of the infrared spectral energy (background, targets, decoys, atmospheric transmission) being emitted from various targets/backgrounds scenarios is crucial to further IRCM and IRCCM improvements.

MR series customer’s benefits

Unrivaled radiometric accuracy for reliable quantification of unknown target’s infrared signature

Rapidly evolving targets such as plane, rocket, flare, missile or explosion are moving rapidly over space and typically have unstable radiated intensity. In many cases, it can be difficult to capture the emitted energy with an acceptable level of radiometric accuracy, while being the most important parameter to infrared signature characterization.

For over two decades, the MR series Spectroradiometers have been designed to overcome this challenge and keep being improved to provide our customer the optimal quantification of unknown target’s infrared radiation, or characterization of known scenes as inputs for data bases or radiometric models.



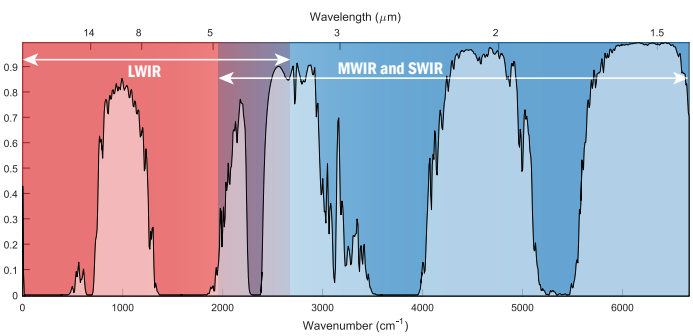
Robust design for reliable operation in all conditions

For smooth and efficient field trials and measurement campaigns, equipment reliability and confidence in instrument performance is mandatory. Robustness and durability differentiate the MR series spectroradiometers from other FTIR spectroradiometers. The rotary scanning mechanism uses frictionless flex-pivots and corner-cube-retroreflectors. The interferometer design has been proven with more than 3600 units produced and over 400 billion of scan cycles successfully achieved. The permanently aligned interferometer shows both outstanding stability of radiometric response and high reliability. Since it is balanced with respect to its center of rotation, the MR interferometer can be operated in any orientation.

Wide Spectral range for complete atmospheric windows coverage

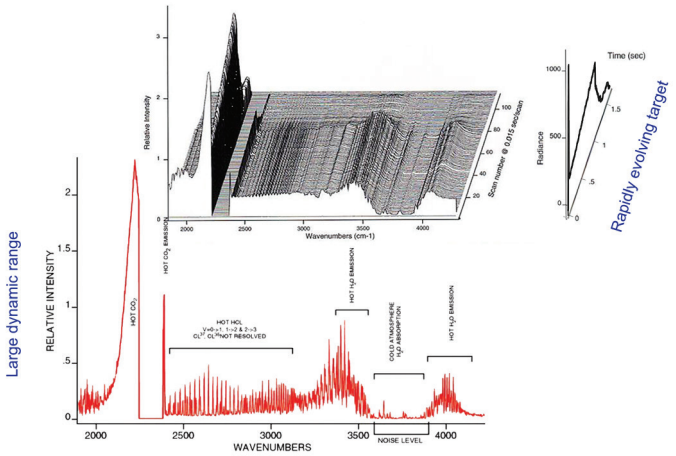
Covering the three main atmospheric windows with a single instrument, from 1.5 to 14 µm extends the range of possible infrared emitted measurement applications.

The MR series FTIR spectroradiometer is composed of a 4 ports Michelson interferometer, which allows simultaneous data acquisition from a MCT and an InSb cryogenic detector to cover the LWIR to SWIR spectral range out of every measurement. The two detectors are completely independent from each other's and feature their own lenses, filter holder and field stop aperture wheel so each detector are optimized for best performances.

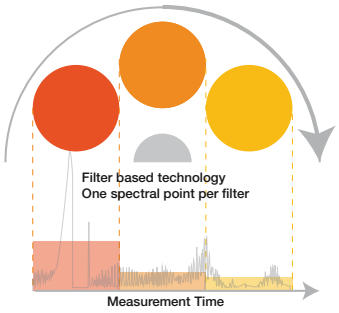


Atmospheric transmission

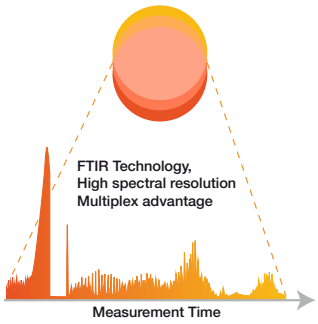
MR series customer's benefits



Canadian rocket spectral signature



Filter based spectroradiometer



FTIR spectroradiometer

Adjustable spectral resolution for chemical discrimination and time resolution

Each target has its own spectral and temporal signature. For some applications such as pyrotechnics flares development, or rocket launch phases analysis, the knowledge of the spectro-temporal evolution is essential. For instance the infrared spectral signature of a rocket evolves over time due to the different combustion phases. Precise knowledge of the infrared signature phenomenology is a key element for discrimination between targets and decoys.

The configurable spectral resolution from 1 cm^{-1} to 32 cm^{-1} opens up different measurement scenarios, from high spectral discrimination of targets components to high temporal resolution of a rapidly changing infrared emitted event.

The spectroradiometer signal to noise is an important characteristic to consider for the infrared characterization of targets. The time allowed for the measurement of a rapidly evolving target is limited by the duration and the fluctuation of the radiation. High signal to noise must be achieved in a short time interval.

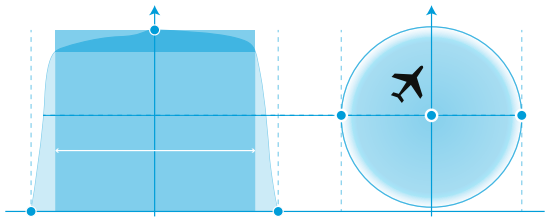
The high signal to noise performance or low noise equivalent spectral radiance (NESR), High measurement rate, high spectral resolution and wide dynamic range of the MR spectroradiometer are essential to accurate measurements of infrared signatures.

Spectral bands relative accuracy for consistent spectral energy distribution

Rapidly evolving targets measurements requires very short measurement interval of time. Moreover, all the spectral bands should be measured simultaneously to ensure sound spectral relative intensity.

Filter bases spectroradiometers measure the spectral bands consecutively. This can lead to spectral band relative intensity errors as the target radiant intensity changes during the measurement time.

The MR series FTIR spectroradiometer technology is ideal for keeping a good relative agreement between the spectral bands since all the wavelengths are measured simultaneously throughout the complete measurement time.



FOV response uniformity: ±7.5% over 85% of total FOV

Field of view response uniformity for accurate measurements of moving targets

Long distances, or small targets do not necessarily fill the instrument field of view (FOV). Moreover, the target can move into the field of view during an acquisition. A non-uniformity of response over the field of view combined with a moving or unstable target can lead to strong impact in terms of radiometric accuracy.

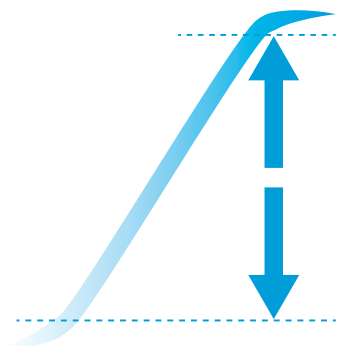
This is why the response of the system over its field of view needs to be uniform, regardless of the position or size of the target.

The MR304 optical configuration provides a uniform response across its field of view. The uniformity of response is better than ± 7.5% over 85% of the field of view.

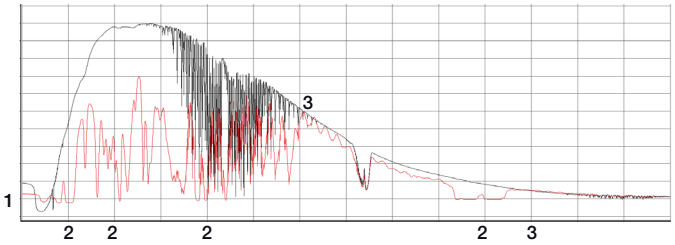
Linearity of response for precise energy quantification

The MR series spectroradiometers are configured with detectors providing a wide dynamic range where the detector response function is linear. The amplification, electronic gain and analog to digital converter are configured to operate the detectors in their linear response range.

The linear response function of the MR spectroradiometer provides a radiometric stability over the spectroradiometer dynamic range, which prevents spectral distortion and radiometric errors to occur.

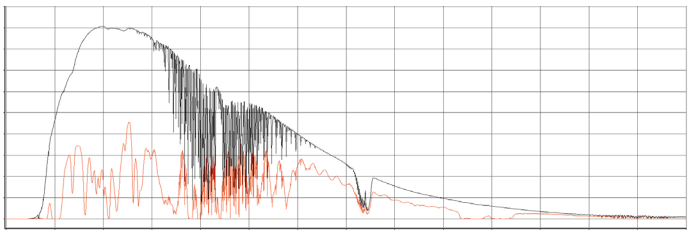


Non-linear response



Reference (black) and polystyrene sample (red) spectrum with non-linear detector

Linear response



Reference (black) and polystyrene sample (red) spectrum with linear detector

The linearity of response across a FTIR dynamic range is crucial to obtain an accurate spectrum measurements. Non-linearity will affect the interference pattern of the Michelson interferometer, which deforms the cosine waves composing the interferogram. Applying a Fourier Transform to a distorted interferogram will result in errors in the energy distribution within the spectral domain. Applying a quadratic calibration in the spectral domain can only partially correct the spectral distortion.

The spectrum in the up side figure demonstrate the non-linearity distortions of the spectrum. The black spectrum was collected from a 500 C blackbody source. The red spectrum includes a polystyrene sample absorbing part of the 500 C blackbody source energy. We can clearly see important spectral energy anomalies.

1. Energy below the detector response cut off
2. Negative energy
3. Ratio of energy of the blackbody + polystyrene spectrum being above the blackbody spectrum

The spectrum in the lower side was collected with a linear detector and represent the correct relative spectral energy between the 500 C blackbody spectrum and the 500 C blackbody + polystyrene sample spectrum.

The ultimate solution to avoid errors due to non-linearity of response is to operate a spectroradiometer with a linear response function.

MR series customer's benefits

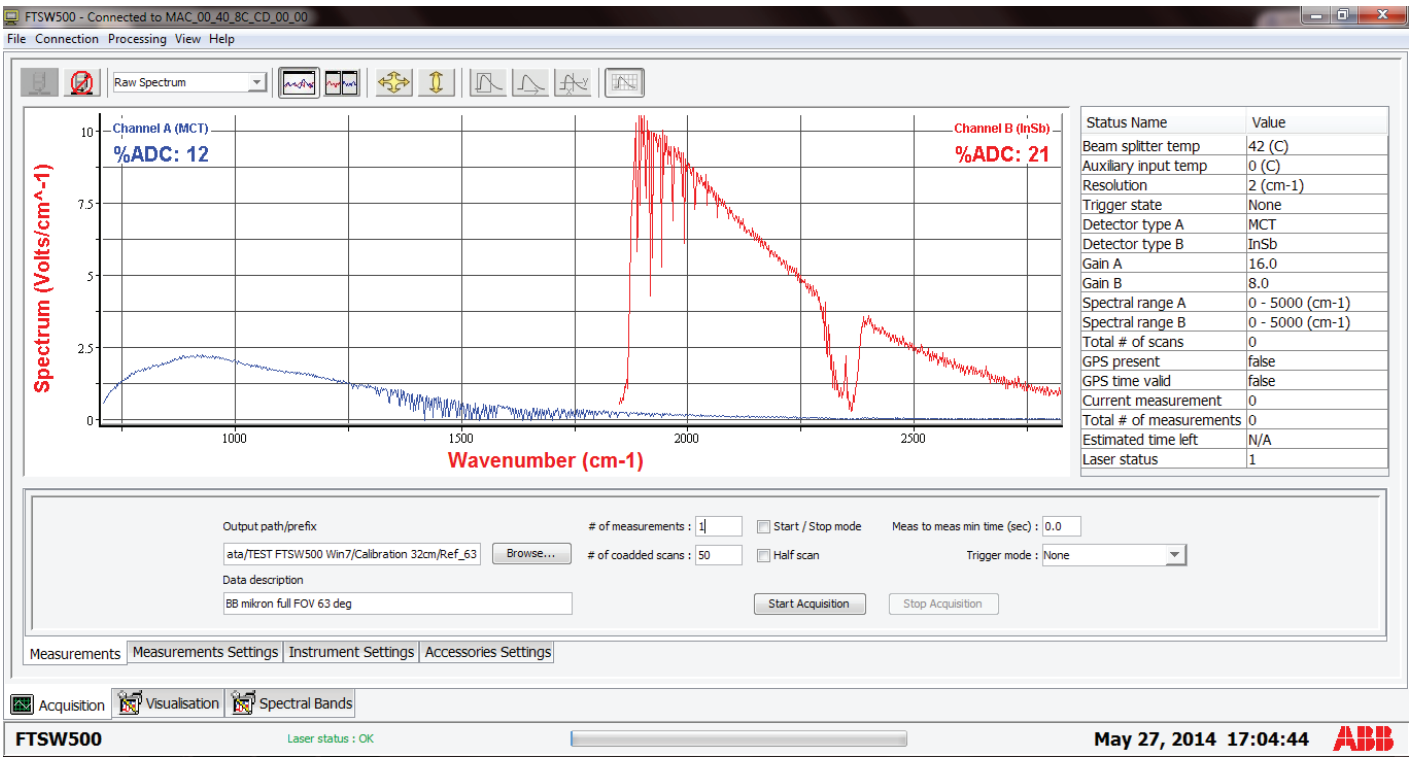
MR series options

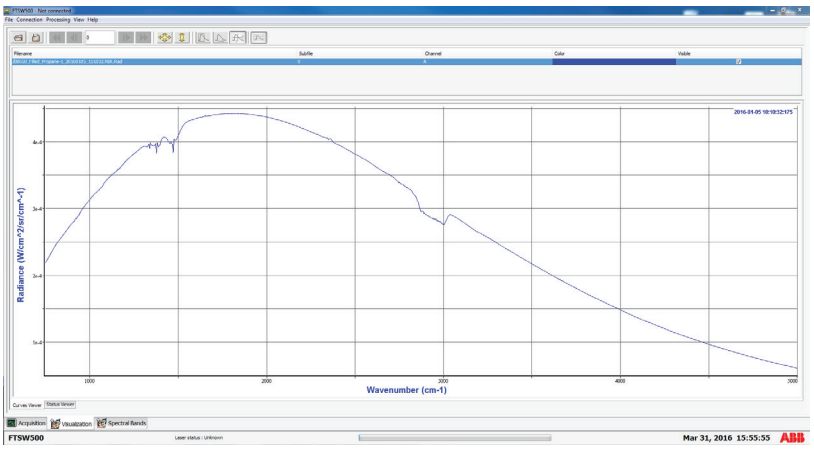
1. **MR series Spectroradiometer**
2. **Input collimator**
3. **AC to DC universal power supply**
4. **Computer and data processor**
5. **Standard Ethernet connection**
6. **Tripod**
7. **Wide angle telescope, 75 mrad, SMY06**
8. **Medium angle telescope, 28 mrad, SMY05**
9. **Narrow angle telescope, 5 mrad, SMY02**
10. **Ocular**
11. **CCD camera**
12. **Monitor**

Modularity to address various targets

The MR304 design ensures high radiometric accuracy of rapidly evolving infrared emitted phenomena. This latest features very high sensitivity, superior time resolution and high uniformity of response across its field of view. The low Noise Equivalent Spectral Radiance (NESR), combined with the fast scanning rate of acquisition and a stable instrument response function, allow accurate measurements of targets emitting low intensity energy and those of rapidly evolving infrared signature. The MR304 opens up the possibility to obtain accurate IR signature of targets without compromising on time resolution.

The MR170 is design with moderate time resolution and high sensitivity to meet the challenging demand of Atmospheric measurements, IR characterization of stable or relatively slow evolving phenomena. The MR170 provides a sound radiometric solution at a comprehensive price.





User friendly software for quick and easy radiance acquisition

The FTSW500 Radiometric Software allows easy instrument control and data acquisition through a 100 Mbit Ethernet link. FTSW500 provides all functionalities for data management and radiometric calibration.

- Control of the instrument
- Real time data acquisition on both channels
- Functionalities to perform instrument diagnostics
- Data analysis and post processing
- Built-in radiometric calibration function
- Real time visualization of interferograms, spectrum and integrated spectral bands
- Built-in data export function to analytic spectroscopy software
- Library of java functions compatible with MATLAB and IDL for further data processing
- Windows 7 compatible

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Sales

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