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DOCUMENT

TK RAM reflectivity and diffuse scattering test campaign – 18-26 GHz

Test report

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1 INTRODUCTION

1.1 Scope

The scope of this document is to report on the results of the **Absorber reflectivity and scattering test campaign** performed at ESTEC, in support to the Microwave Sounder instrument of the MetOp-Second Generation mission.

In particular, the document will provide the following information

- Test Article Overview
- Test Facility General Description
- Test Configurations
- Test Results
- Accuracy assessment

1.2 Applicable Documents

[AD1] - n/a

1.3 Reference Documents

[RD1] - http://www.terahertz.co.uk/index.php?option=com_content&view=article&id=145&Itemid=448

1.4 Acronyms and Abbreviations

BW	Bandwidth
CATR	Compact Antenna Test Range
CW	Continuous Wave
DUT	Device Under Test
IF	Intermediate Frequency
MWS	Microwave Sounder
PNA	Performance Network Analyser
QO	Quasi Optical
QOB	Quasi Optical Bench
RAM	Radar Absorbing Material
RF	Radio Frequency
STD	Standard deviation
TR	Test Report

2 TEST ARTICLE

2.1 General description

In support to the MWS instrument of the MetOp-SG mission, measurements of the reflectivity and diffuse scattering of the radar absorbing material (RAM) used in the instrument at 23 GHz were requested.

The RAM is manufactured by Thomas Keating Ltd. As individual tiles of 100x100m. A sample of 300x300 mm was manufactured by clamping 3x3 tiles. Details of the RAM can be found in [RD1]. In the following sections, the RAM will be called TK-RAM.

Results of reflectivity measurements in the 18-26 GHz band and in particular at 23 GHz will be presented in this TR.

Figure 2-1. Detail of the TK RAM absorber

3 TEST FACILITY DESCRIPTION

3.1 Microwave material RF characterization test facility

The Microwave Material RF characterization free space test facility comprises two corrugated feeds and grids with collimating elliptical mirrors which focus the beam at the sample position. The set-up is used in conjunction with the Compact Antenna Test Range (CATR) positioner. It allows polarization measurements in transmission and reflection configuration (both monostatic and bistatic).

This facility enables the characterization of materials for antenna radomes, reflectors, Electromagnetic Band Gap structures as well as Frequency /Polarization Selective Surfaces (FSS). In addition, reflection measurements can be performed over a wide temperature range, up to 500°C

The pair of horns for each frequency band is either directly connected to the Network Analyser (8-50 GHz) or to Solid State Frequency Extenders based on multipliers and mixers (50-110 GHz).

Table 3-1. Main parameters of the test bench

Frequency range [GHz]	6-110 (8 frequency bands)
Sample holder size [mm]	400x400 and 300x300
Typical edge taper over sample [dB]	-35
Typical beam waist diameter [mm]	5λ
Cross polarization purity [dB]	-50
Positioner accuracy	0.01° (rotation)
Environment control	21°C ± 2° and 40-60% RH
The bench is located in an anechoic chamber	

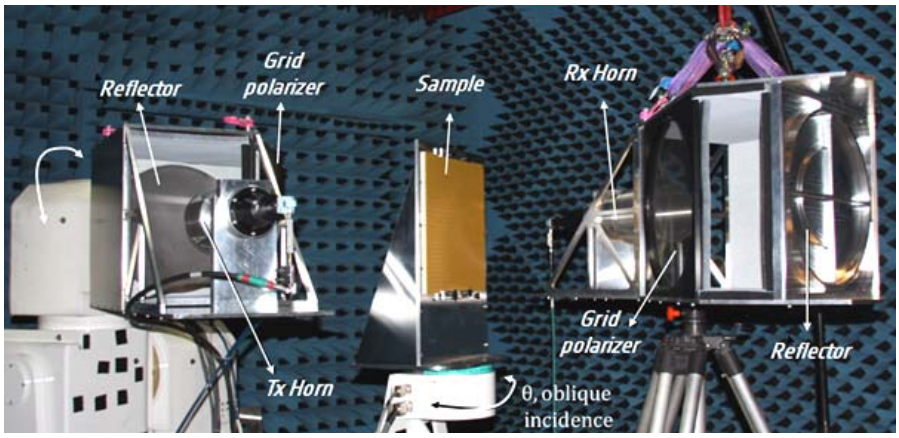

Figure 3-1. ESTEC's Microwave material RF characterization setup

4 TEST CONFIGURATIONS

4.1 Device Under Test

The sample under test is a RF absorbing material commonly used in antenna measurement ranges.

Table 4-1. Samples under test

Sample Number	Sample ID
#4	TK-RAM-16mm_300x300_SN1

Sample orientation definitions

The reflectivity of the samples was been measured for one sample orientation, vertical E field along the x-axis.

4.2 General Test Description

Reflectivity measurements:

- Samples: #4
- Frequencies: 18-26 GHz
- Measurement type: Reflectivity
- Monostatic (Samples: #1 to #10)
    - Normal incidence 0 deg
- Bi-static (Samples: #3, #4, #7)
    - Specular: 22.5 to 75 deg
- Diffuse scattering (Samples: #3, #4, #7):
        - 22.5 deg incidence: 22.5 to 75 deg scattering
        - 45 deg incidence: 22.5 to 75 deg scattering
        - 65 deg incidence: 22.5 to 75 deg scattering
- Sample orientation: Vertical

Bi-static and diffuse scattering measurements:

#4 TK-RAM: sample of interest

4.3 Test environmental conditions

All test operations were performed within the following environmental conditions:

Temperature:	21°C ± 2°C;
Pressure:	720/815 mmHg;
Relative humidity:	50% ± 10%;

4.4 Test setup

Due to the nature of the QO bench used for the measurements, a calibration sample shall be used to derive the material properties. The reflection properties are calculated as the ratio between the S11 parameter of the sample and the S11 of a reflection standard (aluminium plate).

The following measurements were performed with the Quasi-optical bench described in section 3.1

4.4.1 Monostatic configuration

A picture of the bench is monostatic configuration depicted in Figure 4-1.

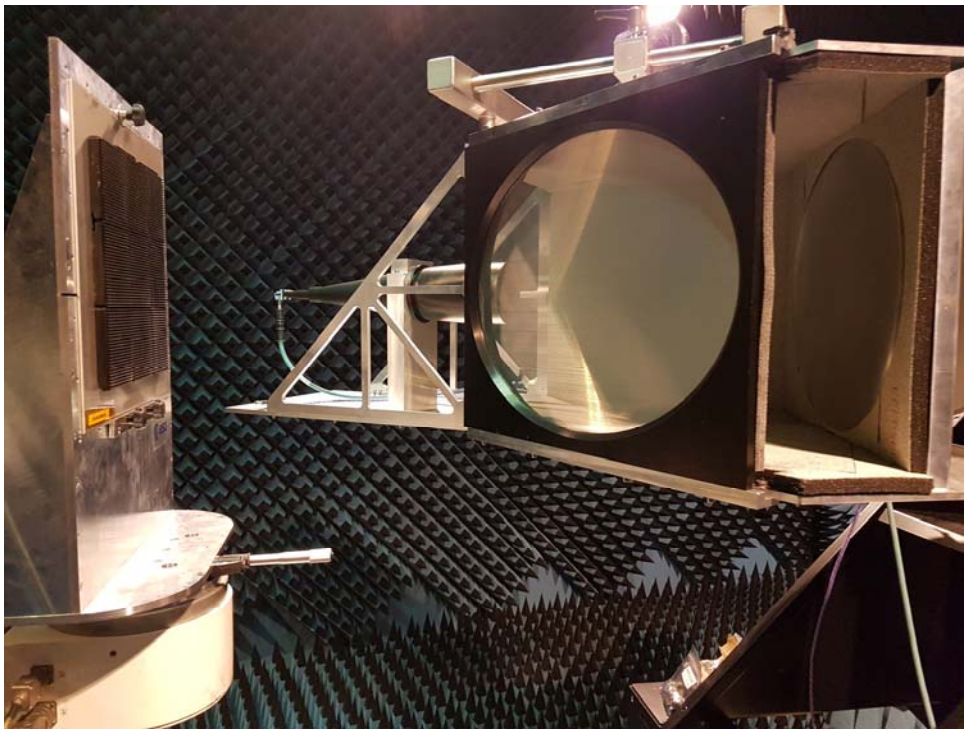

Figure 4-1. Set-up for monostatic reflection measurements: 18-26 GHz

4.4.2 Bi-static configuration

In order to assess the angular performance of the samples (specular and diffuse scattering), the bench is arranged in a bi-static configuration, as shown in Figure 4-2.

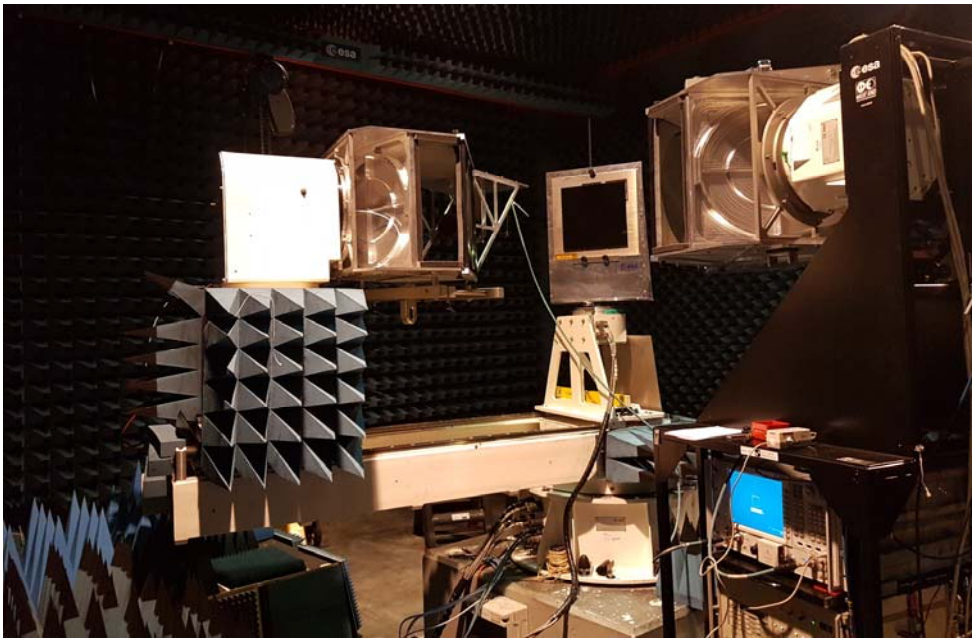

Figure 4-2. Set-up for bi-static reflection measurements, 45 deg incidence

By independently changing the angle of incidence and angle of measurement, both specular and diffuse scattering measurements were performed.

Due to a physical limitation, the minimum specular angle that can be measured is 22.5 deg. A picture of the TX and RX modules for 22.5 deg reflection measurements is shown in Figure 4-3.

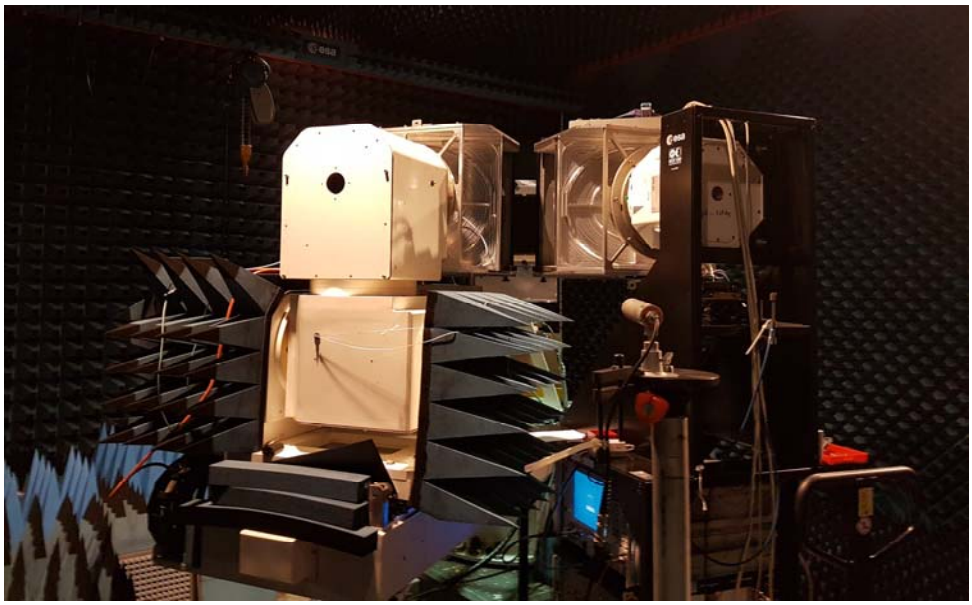

Figure 4-3. Configuration of the TX and RX modules for 22.5 deg measurements

5 TEST RESULTS

In the following sections, results of the monostatic reflectivity (section 5.1), bi-static specular reflectivity (section 5.2) and diffuse scattering (section 5.3) in the 18-26 GHz band are presented.

The results are presented in two forms:

- Reflectivity vs frequency range for different angles of incidence
- Reflectivity vs angle of incidence at 23 GHz, frequency of interest for MetOp-SG

5.1 Monostatic reflectivity measurements at 18-26 GHz

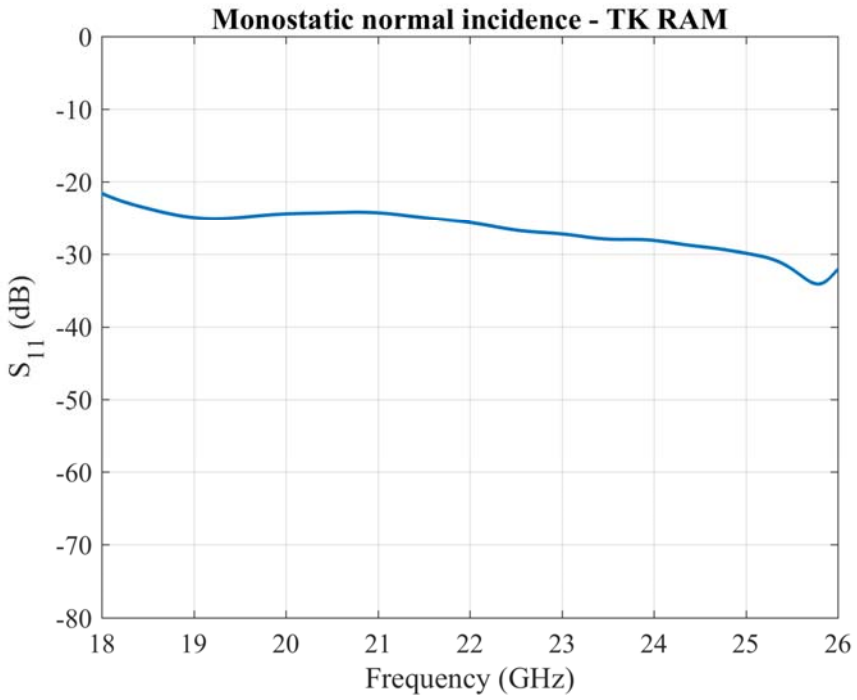

Figure 5-1. Monostatic reflectivity measurements. Comparison between samples and TK-RAM

Results are consistent with the measurements performed by Axel Murk at the IAP and presented in TK's website [RD1].

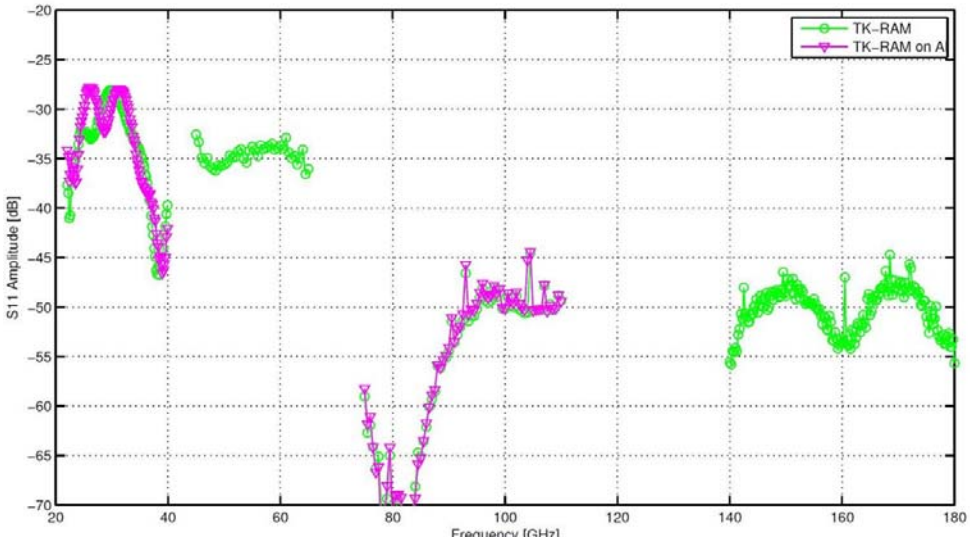

Figure 5-2. Monostatic reflectivity measurements performed at IAP. Source [RD1]

5.2 Bi-static specular reflectivity measurements at 18-26 GHz

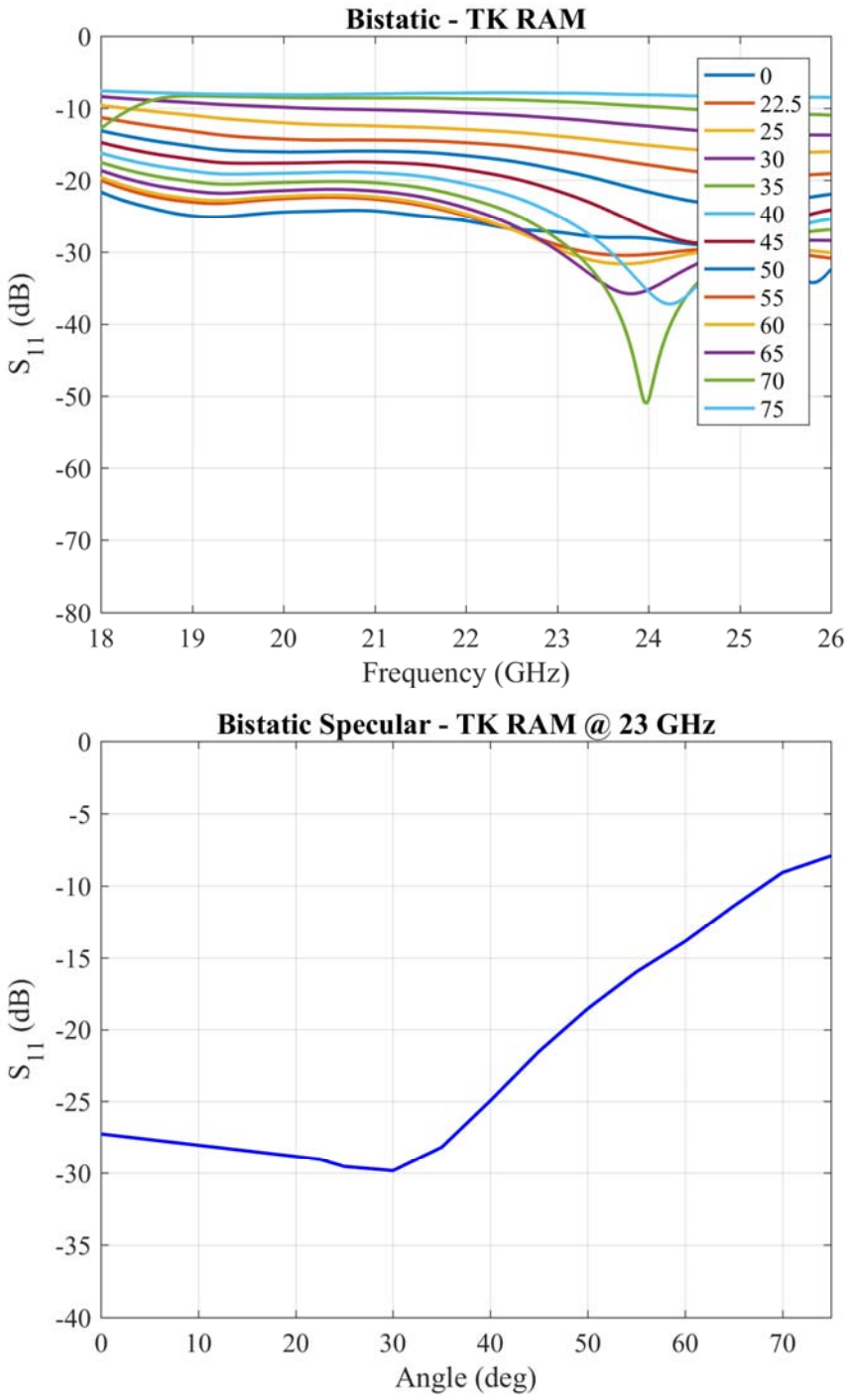

Figure 5-3. Bi-static specular reflectivity: TK RAM

Results of the bi-static measurements for the metal plate are presented normalised to the monostatic configuration. This gives an indication of the relative alignment of the modules and sample.
Since the bi-static measurements of the samples are a relative measurement with respect to the bi-static signal of the plate at each frequency, the misalignment will play a very small role in the sample measurements only affected by the thickness of the sample.
For very accurate measurements, this technique could be used to improve the alignment.

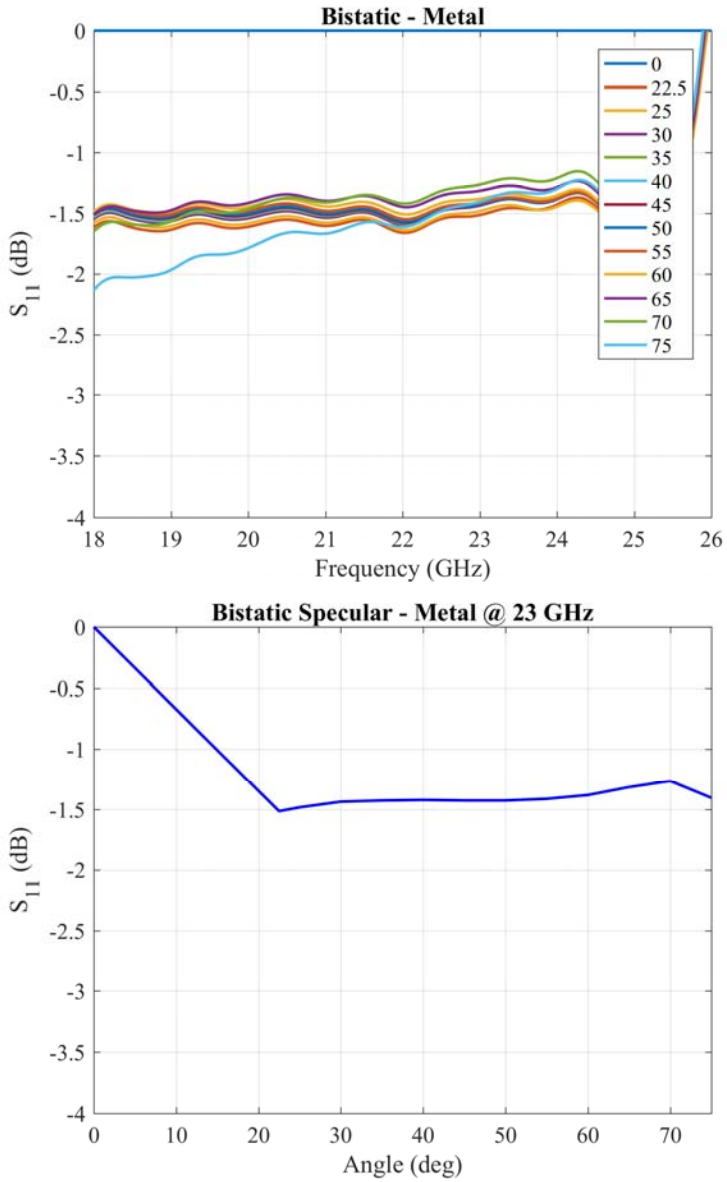

Figure 5-4. Bi-static specular reflectivity: metal plate

5.3 Bi-static diffuse scattering measurements at 23 GHz

In this section results of the diffuse scattering at 23 GHz are presented. Measurements were performed over the whole frequency band and, therefore, similar plots can be extracted for any other frequency between 18 and 26 GHz.

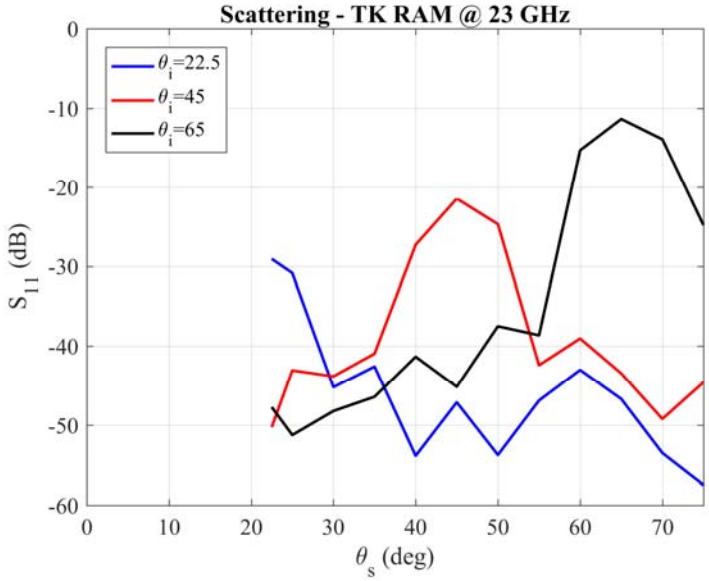

Figure 5-5. Bi-static diffuse scattering reflectivity at 23GHz: TK RAM

For the shake of completeness, results of the diffuse scattering of the metal plate are reported.

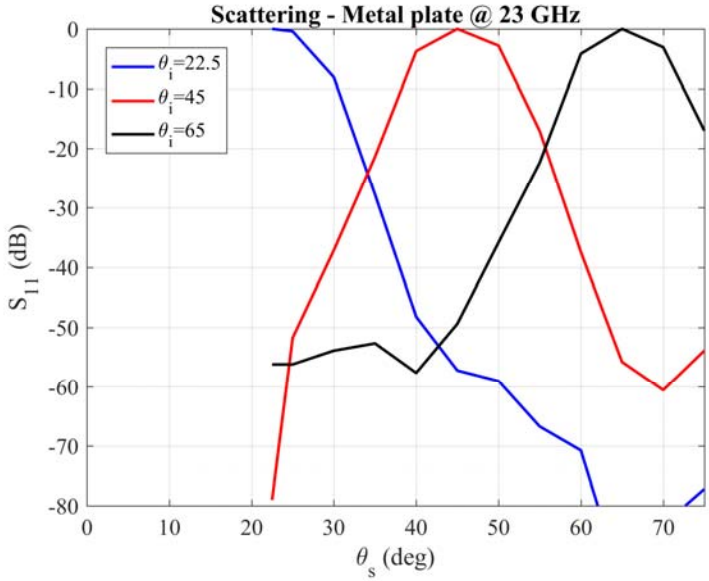

Figure 5-6. Bi-static diffuse scattering reflectivity at 23 GHz: Metal plate

5.4 Measurement uncertainty

In order to assess the repeatability of the measurement, 8 independent measurements of the TK-RAM absorber were acquired. Results are presented in Figure 5-7, where the peak to peak variation of the 8 traces is in the order or 0.1 dB.
Due to the lengthy and manual process, no repeatability measurements were performed in bi-static configuration, but considering the accuracy in the positioning of the motors, similar values as the monostatic configuration are expected.

5.4.1 Repeatability

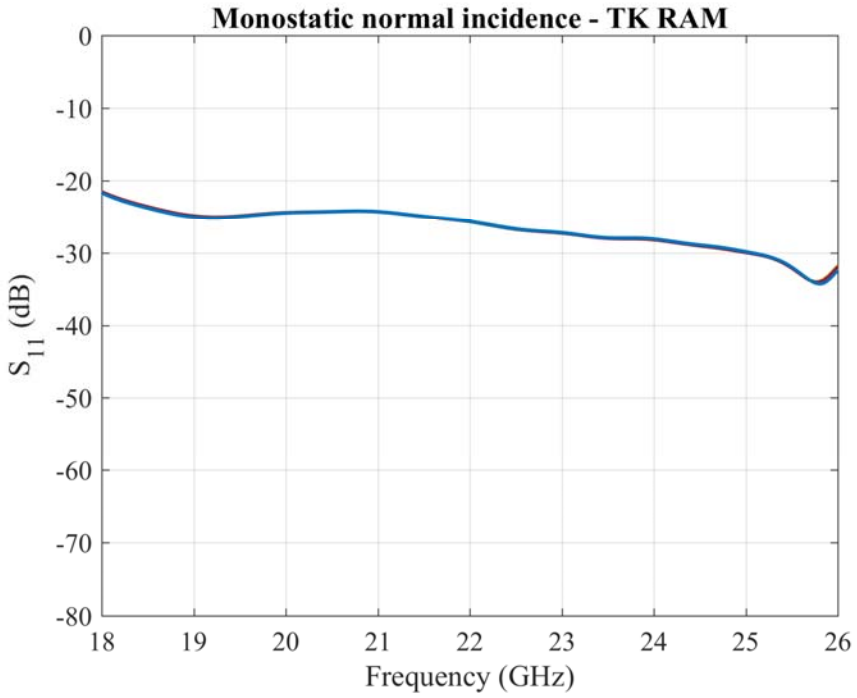

Figure 5-7. Repeatability of the TK-RAM reflectivity

Remarks and conclusions

This test report describes in detail the test setup and test results of the absorber reflectivity test campaign performed at the ESTEC Microwave material RF characterization test facility in Noordwijk, The Netherlands.

A comparison between the performance of the difference absorbers is provided for monostatic reflectivity and bi-static specular and diffuse scattering for 22.5, 45 and 65 deg angles of incidence.

Results are extracted for 23 GHz, which is the frequency of interest of MWS. In particular the reflectivity of the TK-RAM absorber varies from -27 dB at normal incidence, up to -8 dB at 75 deg. In the diffuse scattering, it is confirmed the peak of the reflectivity is at the specular angle.
The results are consistent with the normal incidence reflectivity measurements performed by Axel Murk at the IAP and presented in TK's website [RD1].

From the repeatability analysis conducted during the test campaign, it is concluded that the repeatability is in the order of 0.1 dB.

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