RF and thermal aspects of the ground calibration system for the Microwave Sounder Instrument

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Abstract—We present the RF and thermal design of the ground calibration targets for the Microwave Sounder (MWS) instrument series. MWS is a cross track scanning passive radiometer, operating from 23 to 229 GHz, and is one of the three millimetre and sub millimeter wave instruments of the EUMETSAT/ESA MetOp 2nd Generation programme. These instruments will provide critical information on atmospheric temperature and water vapour content, a major input to numerical weather prediction. Accurate calibration of MWS to reduce the returned temperature uncertainty to ± 0.1 K is required by the data users. A consortium, comprising the RAL Space department at the STFC Rutherford Appleton Laboratory and Magna Parva Ltd., are working under contract to Airbus Defence and Space (UK) to provide ground calibration apparatus for MWS. This will permit pre-launch instrument level calibration under thermal vacuum conditions. The calibration system contains a "cold" black body target, operating at close to 80 K, which replaces the view of cold space and a "Earth" target, which is variable in temperature from 80 to 315K. The cold target is moveable along a $\pm 3^{o}$ arc, and Earth target can be moved from $\pm 50^{o}$ with respect to nadir to simulate different angles on incidence on the planet's surface during the scan. The targets' absorbing structures are made from 41 mm high aluminium pyramids coated with an Eccosorb CR series iron loaded epoxy. Ansys HFSS is used to optimise the pyramid dimensions and coating thickness to reduce the normal incidence, polarisation independent, return loss to better than -45 dB. Three blade servers each with 512 GB RAM were used to reduce computational times during the optimisation process. In house VNA reflectivity measurements using a quasi-optical network have confirmed that the required return loss is achieved. The target's diameter of 480 mm accommodates the -35 dB contour of the largest, lowest frequency, MWS beam. It is necessary to place the targets at the bottom of temperature controlled cylindrical baffles to reduce thermal gradients in the Eccosorb arising from incoming thermal infrared radiation [1]. These cylinders are 700 mm in depth, and their infrared absorbing walls are held at the same temperature as the calibration loads by means of a common liquid nitrogen/helium gas gap/ radiation shield [2] arrangement. Varying the pressure of the helium gas controls the thermal conductance, and so reduces the electric heater power required for intermediate temperatures. This novel approach eliminates the thermal instabilities arising when using a combination of liquid nitrogen and electrical heaters to achieve temperatures above 80 K. Our presentation will compare the predicted RF return loss and results, as well as the design approach used to minimise thermal gradients in the absorber and the ≈0.1 K level effects on the equivalent radiometric temperatures of the calibration loads.

[1]: Axel Murk *et al.*, "Temperature/Absorption Cross Integrals and the Validation of Radiometric Temperatures for Space-Based Radiometers", Proc. 10th European Conf. Antennas and Propagation (EuCAP), pp. 1 - 3 (2016)

[2]: N. Melzack *et al.*, "Variable Temperature Blackbodies via Variable Conductance: Thermal Design, Modelling and Testing" Int J Thermophys (2017) DOI 10.1007/s10765-016-2167-5