ON-BOARD CALIBRATION NOISE SOURCES FOR THE GLOBAL PRECIPITATION MEASUREMENT (GPM) MICROWAVE IMAGER (GMI)

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1. INTRODUCTION

The Global Precipitation Measurement (GPM) Microwave Imager (GMI) will fly on the GPM core spacecraft to be launched in 2013 and the low-inclination spacecraft to be launched in 2014 [1,2]. The GMI radiometer is a conically scanning microwave radiometer covering several bands from 10 to 183 GHz. The two primary on-board calibration targets are a warm load black-body and cold sky reflector. Additionally, the lower-frequency channels (10, 18, 23 and 36 GHz) include coupled noise sources [3]. This is the first time waveguide coupled noise sources and free space black bodies will be incorporated together in a space. In normal operation they will be turned on and off during the calibration portion of alternating antenna azimuth scans. Thus, every two scans, four calibration points are observed by the radiometers: warm load, cold sky, warm load + noise diode, and cold sky + noise diode. This unique ability will provide the potential to study several calibration problems while on-orbit:

- Receiver non-linearity can be tracked using a three- or four-point calibration
- Warm load thermal transients and their frequency dependence can be monitored using the noise sources
- Long-term noise source stability can be monitored using the warm and cold targets

This paper summarizes the design and testing of the noise sources prior to integration into GMI.

2. GMI NOISE SOURCES

The GMI instrument has noise sources at 10, 18 & 23 (using a dual-band unit) and 36 GHz in both vertical and horizontal polarizations. Each source is located in-line between the feed horn's orthomode transducer (OMT) and the input filter to the RF receivers. This location allows the noise sources to be used to measure radiometer gain referenced behind the feedhorn. Their physical location is inside

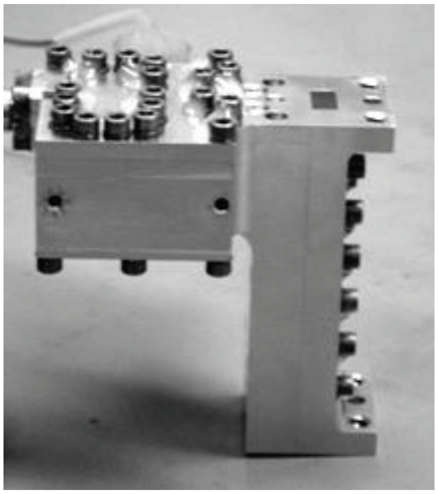

Fig. 1. GMI noise source for one 36 GHz radiometer polarization channel.

thermal blanketing which blocks direct solar or Earth radiation from impinging on the package and should thus be relatively stable, even when entering or existing eclipse.

A photograph of the 36 GHz unit is shown in Fig. 1. The noise is generated by a microwave noise diode in hybrid packaging whose output is coupled into the signal path using a waveguide directional coupler. To track its physical temperature, the noise diode housing is instrumented with a temperature sensor located near the noise diode and its circuit substrate. The noise sources are required to have an ENT temperature coefficient < 0.03 dB/^{o}C or < 1.4 K/ ^{o}C. The measured ENT temperature coefficient is < 0.3 K/ ^{o}C. It is also important for the noise source to have little or no change in insertion loss or return loss when turned on or off. Changes in these parameters would effectively change the radiometer gain and offset while trying to measure it. The insertion loss is <0.1 dB and return loss <-35 dB. The OFF-ON differences are shown in Fig. 2.

3. APPLICATION

Possessing both a conventional warm load and cold sky reflector pair and the coupled noise sources opens the door for a number of potential calibration studies.

3.1 Nonlinearity monitoring

Detector diodes are known to have a slightly nonlinear transfer function of input power to output voltage [4]. This can be characterized within the radiometer using a gain ratio technique whereby the gain is

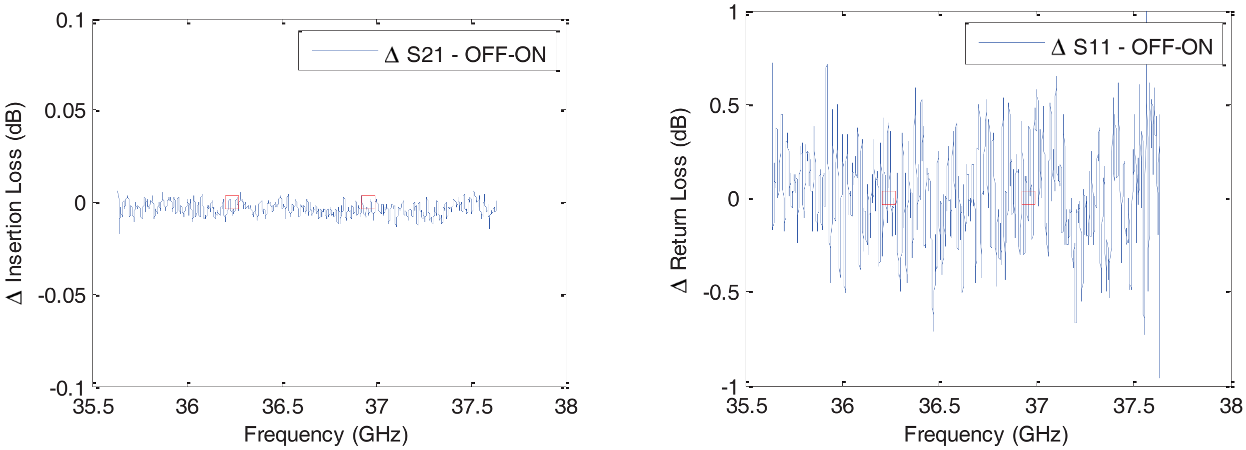

Fig. 2. OFF-ON difference in insertion loss (left) and return loss (right) of GMI 36 GHz noise source.

measured and compared over a range of input antenna temperatures. Using the GMI calibration sources, a gain ratio can be defined:

$$R_{G,S/G,L} = (C_{S+N} - C_S) / (C_{L+N} - C_L)$$

where the C variables are instrument output counts and the subscripts indicate the calibration look: Sky+Noise, Sky only, Load+Noise, and Load only, respectively. The ratio can be monitored over time and temperature for changes which would indicate a change in operating point.

3.2 **Warm load transient monitoring**

Warm loads can exhibit transient thermal gradients due to changes in heat flux loading, which can cause calibration errors, e.g., [5]. Over short time periods (<30 minutes) it may be possible to use the Sky & Sky+Noise two-point calibration to track the warm load brightness temperature to determine if it varies differently from its physical temperature measurements. This is potentially useful for determining if the eclipse has any effect on the warm load. The results could then aid in developing or refining a warm load correction algorithm.

3.3 **Long term noise diode tracking with the warm load**

Despite the occasional temperature gradient anomaly, warm loads have been the primary standard for absolute calibration of conical-scanning spaceborne radiometers for three decades. They are true physical standards in the sense that they are designed to have nearly unity microwave emissivity and are typically instrumented with several temperature sensors. Noise sources, on the other hand, are electronic by nature and have exhibited drift or jumps on orbit [6]. The noise diode element within the noise source can change over time due to aging and exposure to the space environment. Thus, using a black-body physical standard to track a noise source over years while on orbit will produce a first of its kind assessment of noise source stability.

4. REFERENCES

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