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A Mobile Implementation of the Polarimetric Scanning Radiometer to Characterize RFI in Protected Frequency Bands

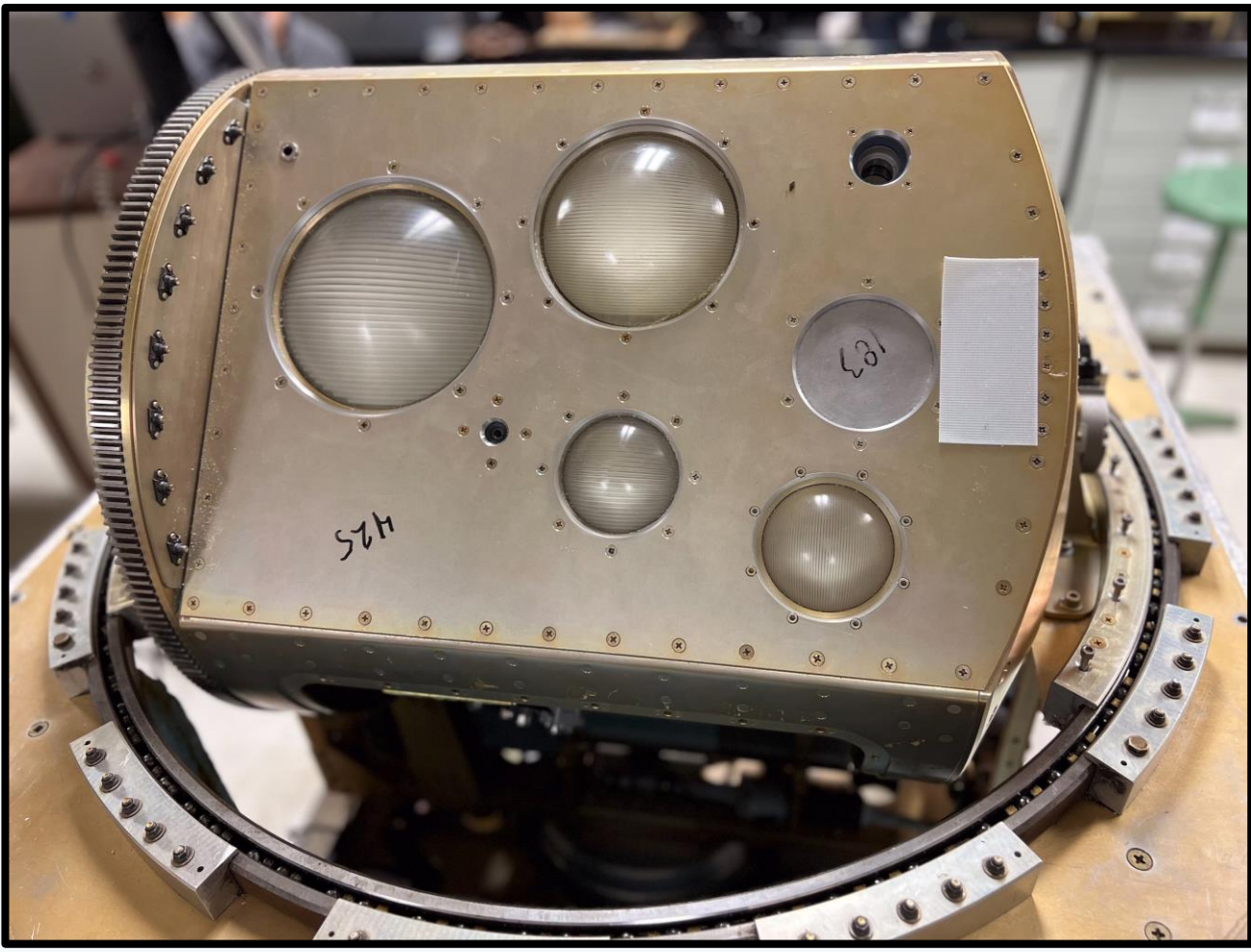


Figure 1. PSR Scanhead



Figure 2. Mobile Platform

Project Overview

The K-Band Spectrum Survey Demonstration Mission addresses the issue of understanding radio frequency interference (RFI) at the ground level which is disruptive to weather forecasting and other scientific applications. By integrating the CET polarimetric scanning radiometer (PSR) into a mobile platform, the project demonstrates the measurement of RFI heat maps in a range of environments: urban, suburban, and rural.

The resonance of water vapor at 22.235 GHz provides a critical capability for accurate and reliable satellite measurements used for weather forecasting. The upper wing of the resonance falls in an internationally protected radio band from 23.6 to 24.0 GHz. This band is allocated for the Earth Exploration-Satellite Service (EESS). RFI can corrupt water vapor measurements and therefore disturb weather forecasts. It is critical to understand the current level of RFI to develop the next generation of NOAA weather satellites [1].

The PSR instrument has historically been used onboard NASA aircraft to collect microwave emission data at frequencies from C-Band through G-Band (6-200 GHz). The unique challenge for this project was to adapt the instrument for operation on a ground-based mobile platform.

Mobile Platform

Power System: 1980 W peak, 900 W continuous from 12 V battery

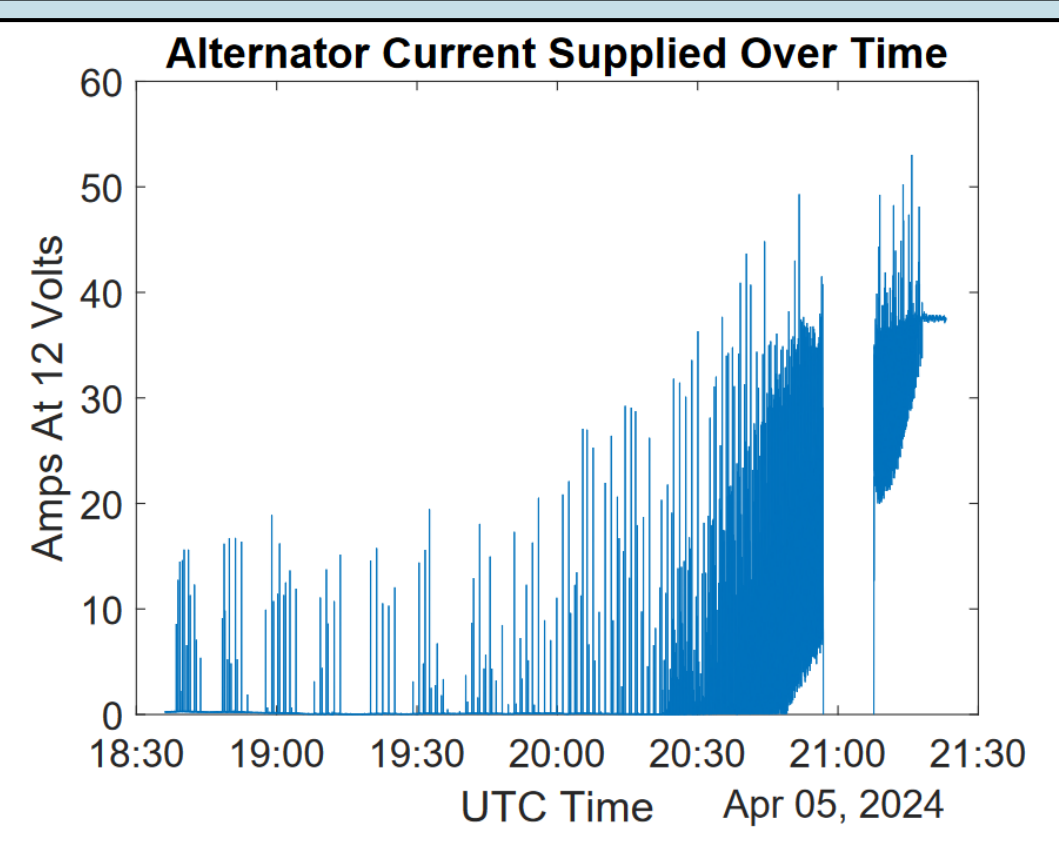
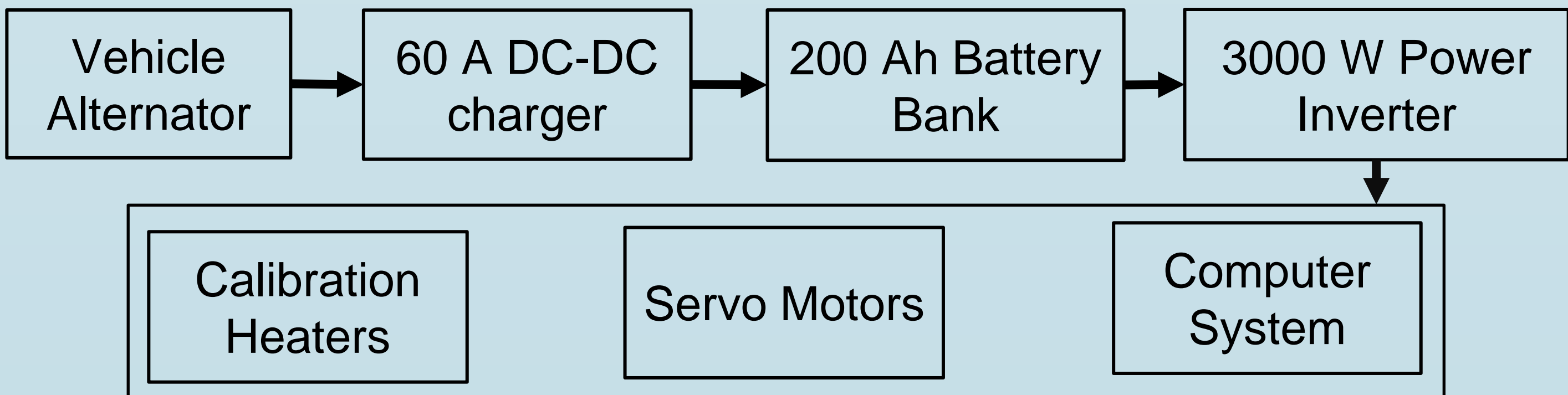


Figure 4.
 Hall probe data of
 alternator current draw
 during local excursion

Local Excursion



Figure 5. O-Records of radiometric data collected during local excursion

The DenvEx24 local excursion objective was to perform a local survey of potential emissions in the 23.6-24.0 GHz frequency band. Beginning at CU in Boulder, brightness temperatures were observed along US-36, Baseline Reservoir, Standley Lake, Federal Blvd, and W. Colfax Ave.

The PSR instrument scanned in conical mode at a beam angle of 83 degrees from Zenith. The O-record in Fig.6 is comprised of 15 conically scanned rasters which provide a convenient means of displaying near planned position indicator (PPI) brightness temperature data. The off-scale data (white) represent potential anthropogenic emission in the EESS allocated band.

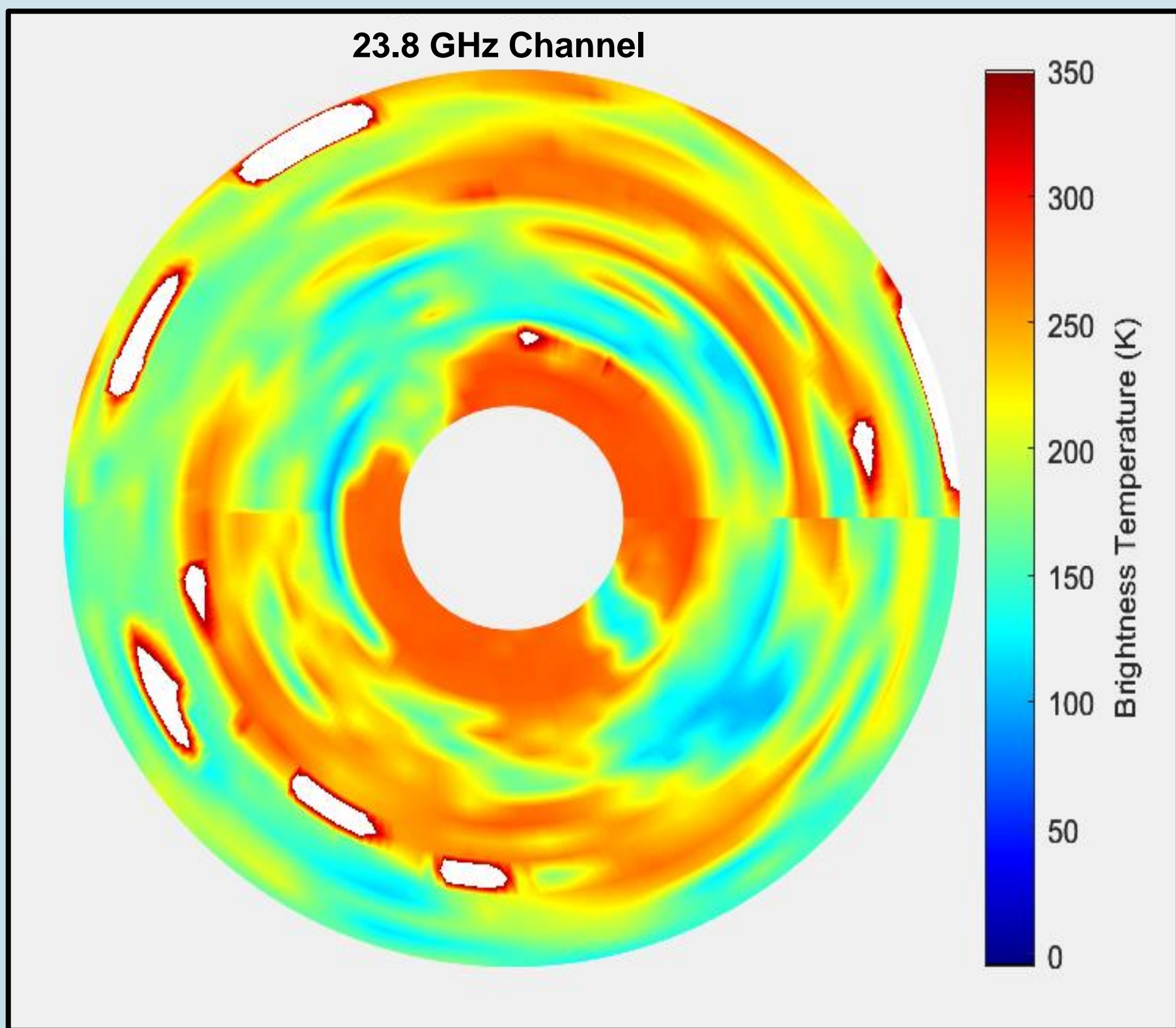
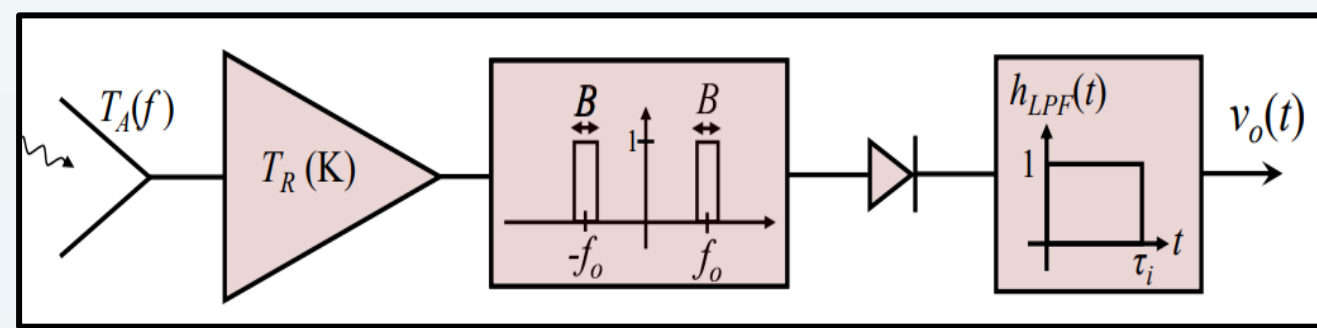


Figure 6. O-Record consisting of 15 revolutions of conical scan

Radiometric Sensitivity



P = kTB
 Measure of Intensity from RF Source

P Power measured
 k Boltzmann's constant
 T Brightness temperature
 B Bandwidth

$$\Delta T_{RMS} = \frac{\sigma_{v_o}}{\frac{\partial \langle v_o(t) \rangle}{\partial T_A}} = \frac{T_{SYS}}{\sqrt{B\tau_i}}$$

ΔT_{RMS}
 Fundamental Limit of Radiometer Sensitivity

T_{SYS} $T_{Antenna} + T_{Receiver}$
 B Bandwidth
 τ_i Integration time

[2]

Instrument Characterization

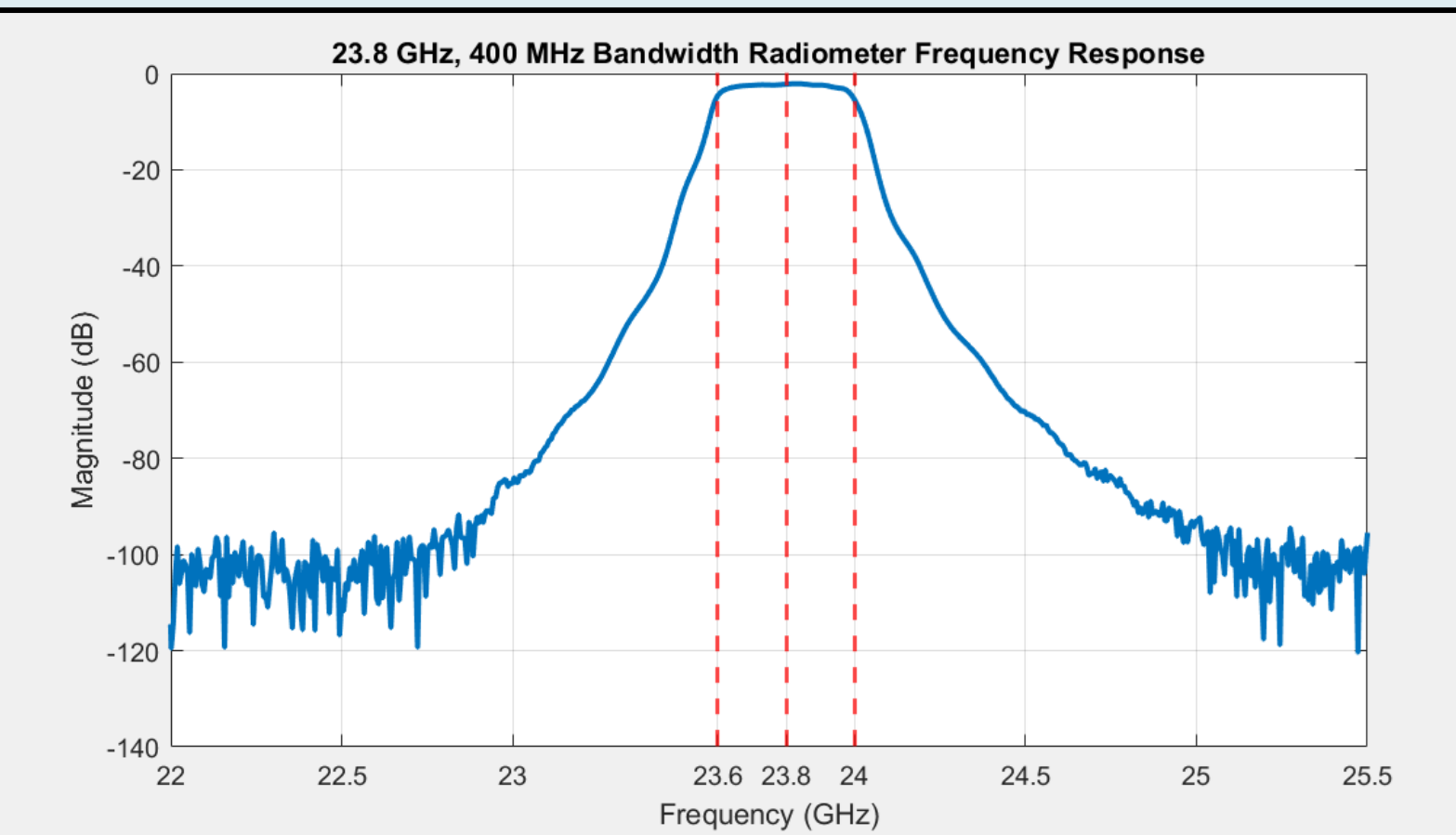


Figure 7. Passband filter response for 23.6-24.0 GHz EESS channel illustrating out-of-band filter response

Condition	Temperature (K)	$\langle \text{Voltage} \rangle$ (V)	σ (mV)
Ambient	290	-0.794	1.335
Liquid Nitrogen	77	-0.362	1.204

$\Delta T_{RMS} = 0.6 \text{ K}$
 Gain = 2 mV/K

Figure 8. In-lab measurement data identifying gain and sensitivity of instrument

Next Steps

- Complete full excursion through downtown Denver and DIA
- Install PSR into CU/CET van
- Improve power system to enable continuous operation
- Upgrade 24 GHz radiometer with hyper-spectral digital spectrometer

References

[1] National Research Council. *Spectrum Management for Science in the 21st Century*. Washington, DC: The National Academies Press, p. 80-85 (2010), <https://doi.org/10.17226/12800>.

[2] A. Gasiewski. (2022) ECEN 5254 [Powerpoint Slides]