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Project Title: A Simulation Study On Low-Cost Water Vapour Radiometry

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Outline

- Atmospheric Water Vapour
- Different types of radiometers
- System development and Progress to date

Atmospheric Water Vapour

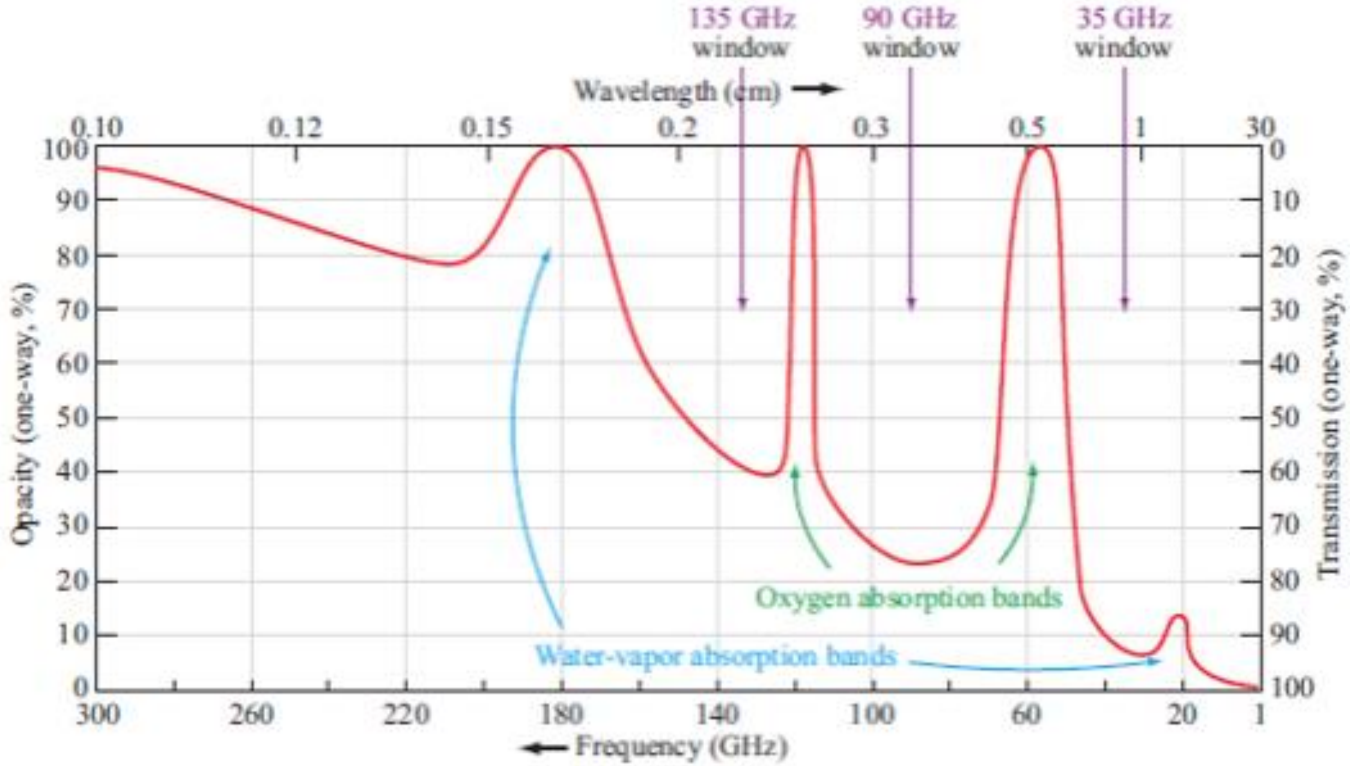

Figure 1: Zenith opacity of the atmosphere at different frequencies [1].

Atmospheric Water Vapour

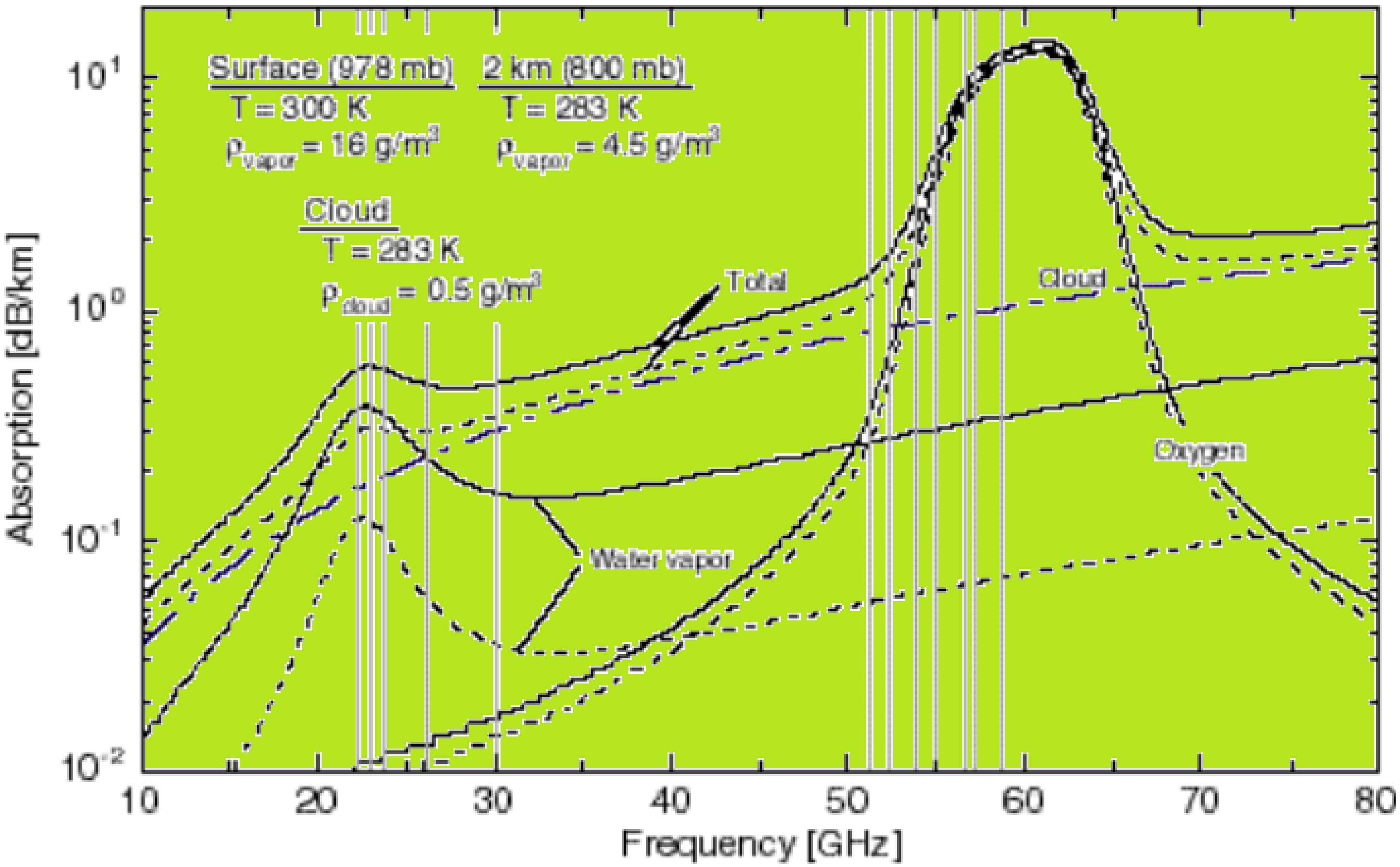

Figure 2: Zenith opacity of the atmosphere at different frequencies [2].

Atmospheric Water Vapour

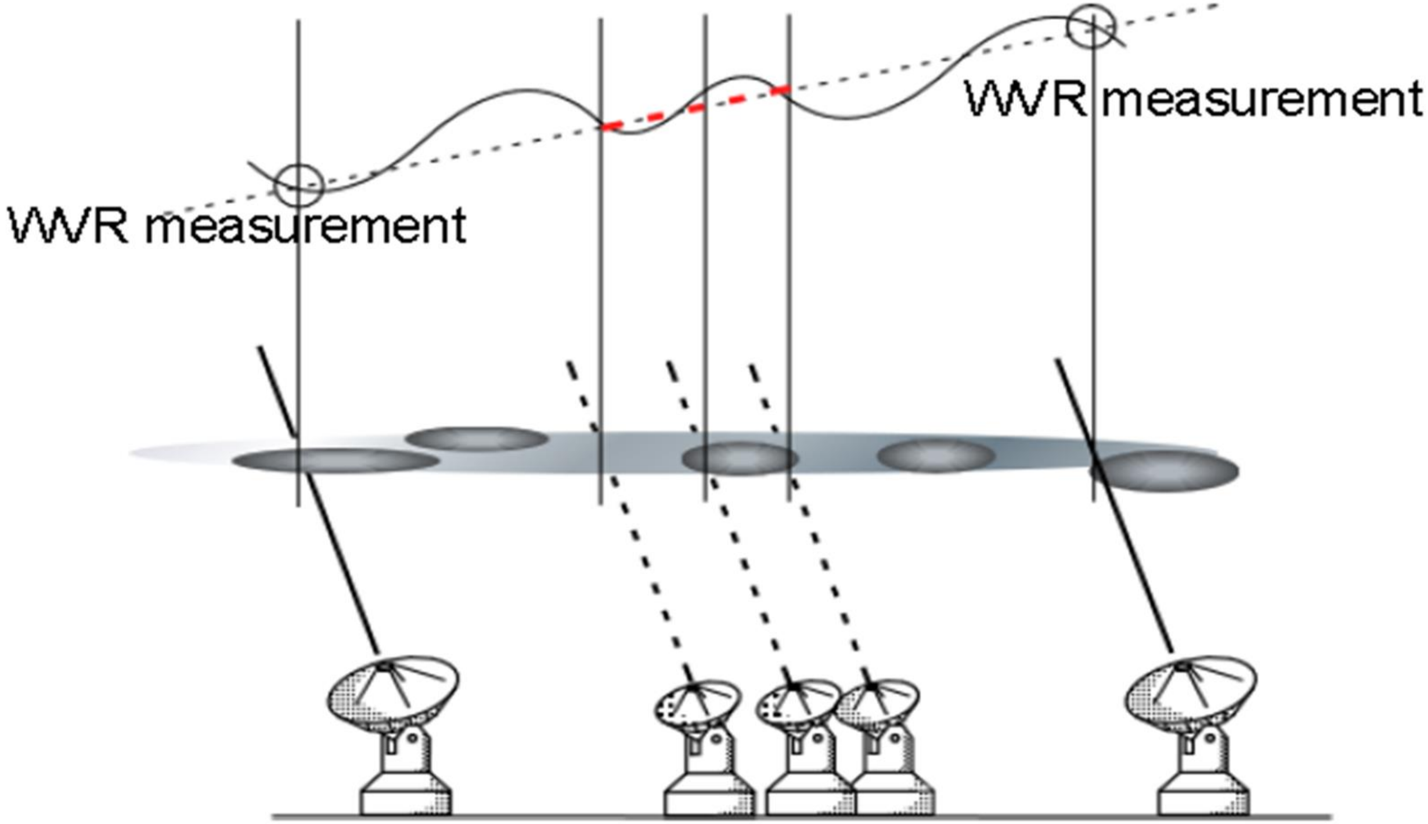

Figure 3: A cartoon of the effect of water on an astronomical signal [3].

Basic radiometer

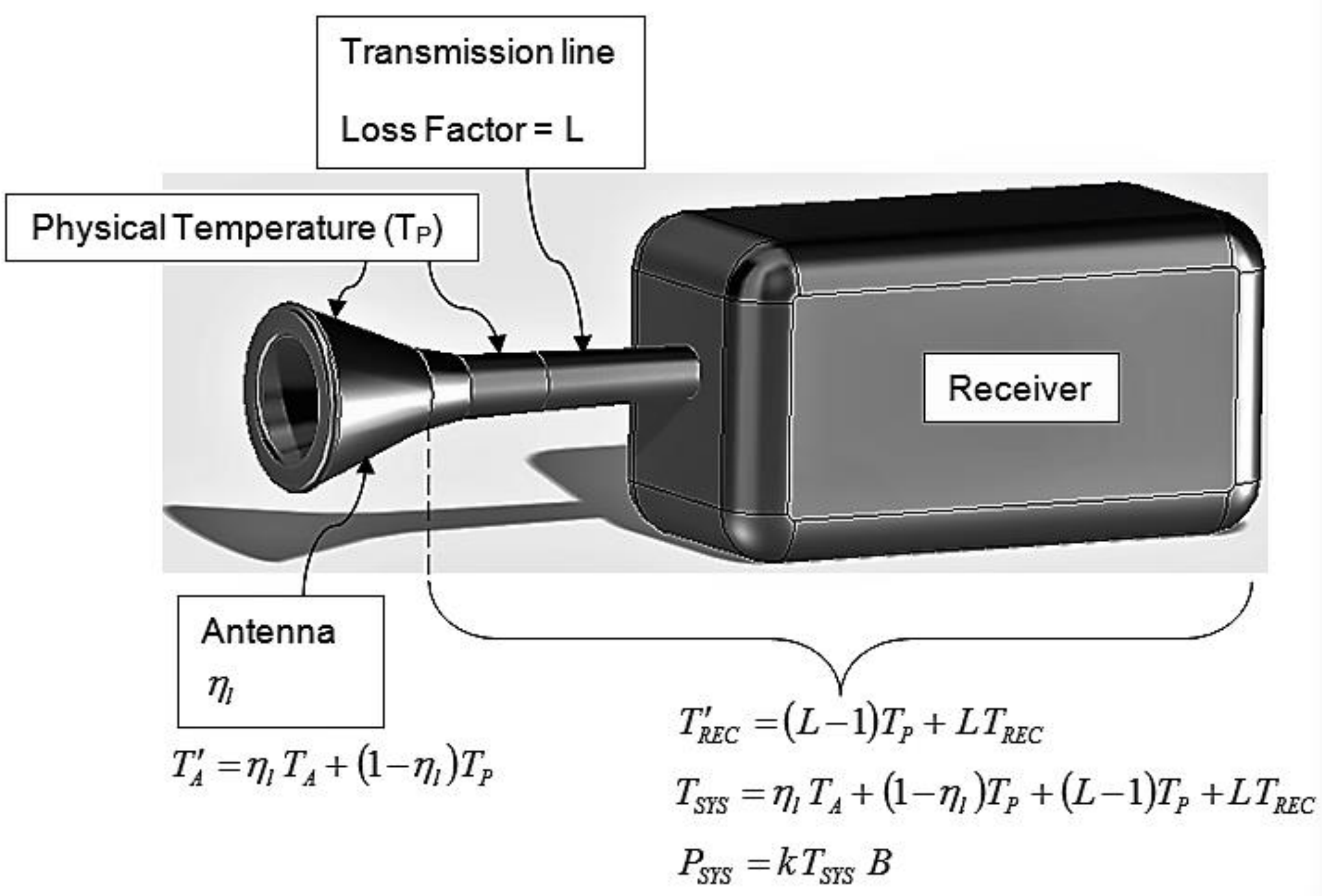

Figure 4: A cartoon display of a basic microwave radiometer

Different types

Table 1: Different types of radiometers and sensitivity formulas.

Radiometer Schematics	Radiometer equations	Radiometric resolution
a) Total power radiometer	$\langle V_o \rangle = k \cdot (T'_A - T_R) \cdot B \cdot G \cdot C_d + Z$	$\Delta T = T_{SYS} \sqrt{\frac{1}{B \cdot \tau} + \left(\frac{\Delta G_S}{G_S}\right)^2}$
b) Dicke radiometer (unbalanced)	$\langle V_o \rangle = \frac{1}{2} \cdot k \cdot (T'_A - T_{REF}) \cdot B \cdot G \cdot C_d$	$\Delta T = \sqrt{\frac{2 \cdot (T_A + T_R)^2}{B \cdot \tau} + \frac{2 \cdot (T_{REF} + T_R)^2}{B \cdot \tau} + (T_A - T_{REF})^2 \cdot \left(\frac{\Delta G_S}{G_S}\right)^2}$
c) Noise injection radiometer	$\langle V_o \rangle = 0$ $T'_A + T_{ON} = T_{REF}$	$\Delta T = \frac{2 \cdot (T_{REF} + T_R)}{\sqrt{B \cdot \tau}}$

System Development

- Noise injection topology will be used.
- Two channels will be used to eliminate the effects of liquid water (ILW).

System development

Table 2: Technical specifications of the water vapour radiometer receiver

Ch1 & 2 Frequency (GHz)	Reference Temperature (K)	IF Bandwidth (MHz)	Noise Figure (dB)	Integration time (ms)	Sensitivity (K)	T_{SYS} (K)	Dicke switching frequency (KHz)
22 & 31.5	313	400	5	50	0.42	953	1

Block diagram

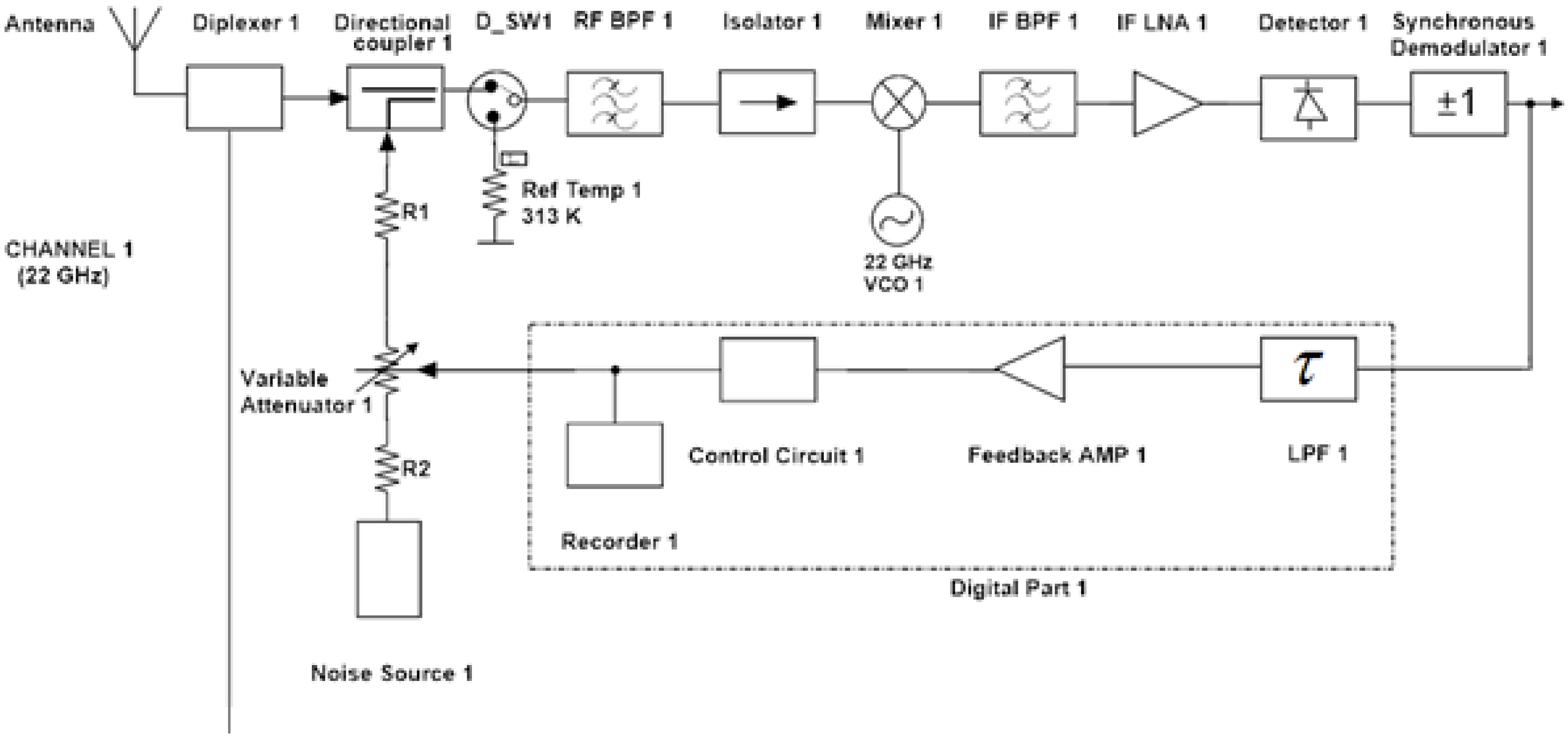

Figure 5: Developed dual-channel WVR channel 1.

Block diagram

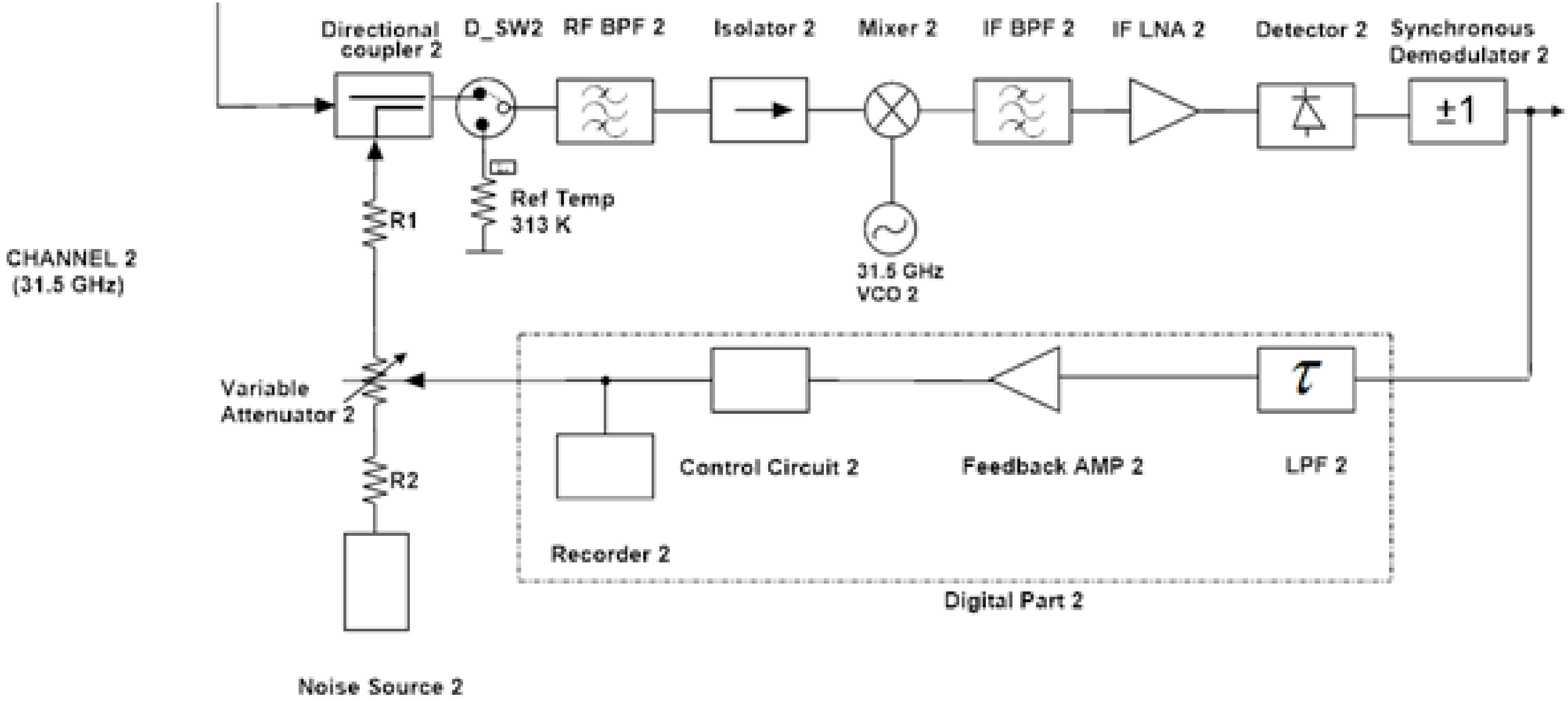

Figure 6: Developed dual-channel WVR channel 2.

Research Objective for Masters

- Develop low-cost methods for water vapour radiometers.

- Do a realistic simulation study on different radiometer topologies.

- Make recommendations.

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Research Questions

- Which state-of-the-art systems are available in practice and what are the costs associated with them?

- Which components are available on the market and which ones should be custom-made for the radiometer?

Research Questions

- Which radiometer topology will give the best radiometric resolution with the commercially available and custom-made components?
- What recommendations can be made after obtaining the results of the developed systems?

Methodology (I)

- Simulate and baseline a TPR operation with ideal components (should correspond to theoretical analysis).

- Draft a list with all commercially available components.

- Simulate the TPR with commercially available components.

Methodology (II)

- The same will be done to complete simulations for each radiometric topology.

- Decide on which components should be custom-made and which components should be bought, to construct the final radiometer.

- Make recommendations, based on the obtained simulation results for each radiometric topology.

References

[1] *F. T. Ulaby, D. G. Long, W. J. Blackwell, C. Elachi, A. K. Fung, C. Ruf, K. Sarabandi, H. A. Zebker, and J. Van Zyl, Microwave Radar and Radiometric Remote Sensing. University of Michigan Press, 2014.*

[2] *W. Vapor and C. L. Water, "Microwave Radiometer Profiler Handbook Evaluation of a New Multi-Frequency Microwave Radiometer for Measuring the Vertical Distribution of," 2002.*

[3] R. Kawabe and M. Saito, "Phase Calibration with WVRs for the ACA Atacama Compact Array (ACA)," 2006.

Thank you! Any questions?