Development of an Integrated Dual-Band Schottky Receiver in the Terahertz Regime for Use in Cubesat Systems

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Molecular clouds are the coldest form of matter found in the universe and are the heart of the star formation process. Reaching temperatures as low as a few Kelvin, these vast regions are often called “star nurseries” due to their unique environment which allows for the collapse of mass into nascent stars. Molecular clouds are typically comprised of little more than a collection of molecular hydrogen (H_2) and trace elements such as silicon and carbon found in intermittent dust grains. Due to the extremely low temperatures in these regions, observing molecular clouds is a difficult task that relies on the radiation produced by low-energy rotational transitions.

Water vapor (H_2O) is a key tracer of star formation and is of particular interest in learning about the origins of the Earth and our own solar system. Since the ground-state rotational transition of (H_2O) at 556 GHz (0.5 mm) only requires 27 Kelvin of thermal energy between its upper and lower states, it provides an excellent probe of the excitation conditions of the cold gas surrounding birthing stars. This in combination with significant self-absorption due to the high optical depth of the transition provides a complex (H_2O) profile which unveils information about the molecular cloud such as density, temperature, velocity structure, and even geometry.

While (H_2O) is an extremely important spectral line for demystifying molecular clouds, detecting and mapping these signatures is a difficult task. Most notably, the 556 GHz line is completely saturated when looking out from Earth due to the water vapor in our atmosphere. Astronomers have attempted to make observations of this spectral line from balloons launched high above the ground, but even the small amount of water in the atmosphere at this altitude makes observations difficult. The only way to truly avoid atmospheric occlusion in this band is to observe on a satellite in space, which was the primary driver of missions such as SWAS, Odin, and Herschel. However, full-sized satellite missions such as these are prohibitively expensive and are usually are not focused specifically on the 556 GHz line. In order to push further into (H_2O) observations of molecular clouds, technology must be developed to allow for specialized cubesat or smallsat missions which will make observations in this spectral band economically feasible without trading away spatial or spectral resolution.

Here we present the completed design for a low-mass, low-power, highly integrated Schottky diode based coherent receiver system suitable for deployment on cubesats or other smallsat platforms. The current state of coherent Schottky diode receivers are still far too large and consume too much power to be considered for use on these smaller platforms. Through use of a novel packaging system, we have condensed JPL designs for both a modular 520-600 GHz receiver and a 1040-1200 GHz receiver into a single integrated receiver and mixer block. This combined block is pumped by a single local oscillator (LO) and has been shown to have significantly smaller volume and power consumption than the current state-of-the-art while maintaining the noise temperature of its larger counterparts.

Furthermore, we will discuss and present the designs of a Gaussian-optic thermal break which will separate the Schottky diodes from the heat dissipation caused by the LO chain feeding the mixers. We will then present some results of tests and measurements done to the manufactured integrated receiver. Finally, we will conclude with a discussion of future plans for the system and its promising potential for use in cubesat interferometry systems.

REFERENCES

Please use this section to provide references (up to 3 references)

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