Highly-Compact Terahertz Spectrometers on Ultra-Small Platforms

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SmallSats and CubeSats are compact and low-volume, sometimes even similar to a shoe box size, satellites with low-mass, low available power, and have somewhat limited communication and instrumentation capability. The size of the CubeSats is referred in the unit of 'U', where one 'U' is a cube with 10 cm x 10 cm x 10 cm dimensions.

Traditionally, SmallSats and CubeSats and their related instrumentation was primarily confined to undergraduate university research. However, in recent years, the international space agencies have been actively looking into CubeSats and SmallSats as useable platforms to supplement main missions as well as using them for standalone scientific missions. In some cases, they are being used to provide a communication relay platform for the missions where direct to earth (DTE) links are not always feasible. A case in point is the Mars Cube One (MarCO) [1] where two CubeSats were used to provide communications with the main space craft and ground control during high-risk maneuvers and critical events during the recent Insight landing.

Although apparently simplistic, development of scientific instruments on SmallSat and CubeSat platform poses a host of challenges: the instrument needs to be highly compact due to the lack of available space, has to be ultra-low power due to the severe restrictions on DC power availability, and one has to be innovative in the design of the antennas as traditional high gain reflector antennas (for scientific payload as well as for data communication) are not practical for such platforms. Design and development of aperture deployable antennas and other innovative structures are gaining a lot of attention in this regard.

We are developing a fully functional submillimeter-wave standalone scientific instrument as technology demonstrations on a CubeSat platform. Specifically, we are developing a low-mass and low-power 500-600 GHz high-resolution spectrometer instrument capable of remotely measuring water isotopes and deuterium/hydrogen (D/H) ratios on comets. The instrument's 18 cm diameter aperture consists of a novel low-profile leaky-wave lens-based antenna with waveguide feed. A microelectromechanical system (MEMS) based calibration switch is integrated with the receiver front-end along with low-power CMOS-based backend spectrometer circuits. This allows the overall instrument mass and power to be in the range ideal for implementation on ultra-small platforms such as CubeSats.

In this presentation, we will provide the design and implementation of the 500-600 GHz spectrometer instrument with details of innovative packaging solutions, antenna technology, and low-power backend solutions suitable for CubeSat and SmallSat platforms.

REFERENCES

[1] S. Asmar et al., "Mars Cube One (MarCO) Shifting the Paradigm in Relay Deep Space Operations," in the Proceedings of the 14th International Coference on Space Operations (SpaceOps 2016), Daejeon, Korea, May 2016.

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