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Capacitive transducer development for ultrasonic anemometry on Mars

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Abstract

Ultrasonic wind sensors are widely used on Earth due to their full-range accuracy and high measurement frequency. This poster will look at the operation of such sensors and the developments necessary to operate the devices under Martian conditions.

1. Introduction

Previous Mars missions have used either mechanical or thermal anemometry techniques. The moving parts of mechanical anemometers are prone to damage during launch and landing and their inertia makes them unsuited for turbulence studies.
Thermal anemometers have been used successfully on Mars but are difficult to calibrate and susceptible to varying ambient temperatures.
In ultrasonic anemometry, wind speed and sound speed are calculated from two-way time-of-flight measurements between pairs of transducers. Three pairs of transducers are used to return a 3-D wind vector. Ultrasonic anemometry offers high measurement frequency (up to 100 Hz), simple calibration, immunity to drift and 3-D vector measurement.

2. Capacitive Ultrasonic Sensors

Due to the low acoustic impedance of the Martian atmosphere, significant insertion losses occur at both transmitting and receiving transducers. This requires any transducers to be used on Mars to have as low acoustic impedance as possible.

Capacitive ultrasonic transducers have been selected over piezoelectric transducers for their significantly lower acoustic impedance.

Capacitive transducers consist of a metallised polymer film pulled taught against a machined metal backplane. The film is drawn towards the backplane by a DC bias voltage. A varying signal is used on top of the DC bias to oscillate the film; generating acoustic waves.

3. Sensor Optimisation

The performance of these transducers depends on a combination of several factors including film thickness and backplane machining techniques[1].

Thinner films give a greater sensitivity but also increase the resonant frequency of the transducers. The optimum operating frequency to minimise losses to the Martian atmosphere is below 100kHz[2]. Therefore the film tension and backplane roughness need to be selected to achieve this resonant frequency.

We have been developing low-mass ultrasonic transducers for future Mars missions. We present data on the performance of the sensors and instrument design considerations including operating strategy and low-noise electronics.

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References

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