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Pressure and Relative Humidity Measurement Devices for Mars 2020 Rover

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Abstract

One of the scientific payloads onboard the NASA Mars 2020 rover mission is Mars Environmental Dynamic Analyzer (MEDA): a set of environmental sensors for Mars surface weather measurements. Finnish Meteorological Institute (FMI) provides a pressure measurement device (MEDA PS) and a relative humidity measurement device (MEDA HS) for MEDA.

1. Introduction

Mars Environmental Dynamic Analyzer (MEDA) is a set of environmental sensors on board NASA's Mars 2020 rover provided by Spain's Centro de Astrobiología. MEDA's principal goals are to provide continuous measurements that characterize the diurnal to seasonal cycles of local environmental dust properties and near-surface environment. MEDA sensor package is designed to record dust optical properties and multiple atmospheric parameters: wind speed and direction, pressure, relative humidity, air temperature, ground temperature, and radiation in discrete bands of the UV, visible, and IR ranges of the spectrum.

Finnish Meteorological Institute (FMI) provides a pressure measurement device (MEDA PS) and relative humidity measurement device (MEDA HS) for MEDA. Both devices are designed, built and calibrated by FMI. Main scientific goal of both devices is to measure the meteorological phenomena (pressure and humidity) of the Martian atmosphere and complement the previous Mars mission atmospheric measurements for better understanding of the Martian atmospheric conditions.

2 MEDA PS

MEDA PS is pressure measurement device based on silicon micro-machined capacitive Barocap® pressure sensors developed by Vaisala Inc. The measurements are controlled by Vaisala proprietary ASIC. The technology of the Barocap® is well known and it has been used before in 6 missions, including MSL (REMS-P) and Exomars 2016 Schiaparelli lander (DREAMS-P). MEDA PS design is very similar to REMS-P, inheriting some parts also from DREAMS-P.

MEDA PS is located inside the the temperature controlled Instrument Control Unit (ICU) and connected to the atmosphere through a dedicated pipe. The pipe exits the rover body through a small opening in Rover Avionics Mounting Panel with a dust filter. The electronics are protected by box-like Faraday cages. Dimensions of the instrument are 62 mm x 50 mm x 17 mm (height without the pipe) and the total mass is only approximately 40 g. Power consumption of MEDA PS during pressure measurements is 15 mW.

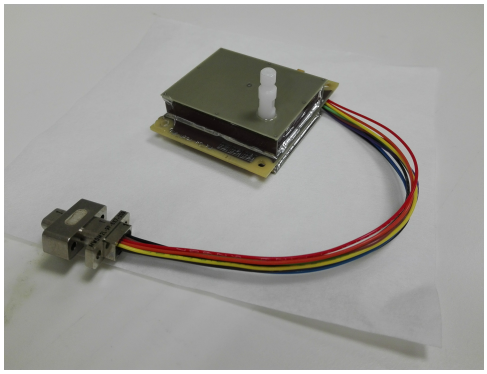

Figure 1: Flight model of MEDA PS.

2.1. MEDA PS Performance

- Measurement range: 1-1200 Pa (optimized for Mars range 400-1200 Pa).
- Accuracy: ±20 Pa from 1-400 Pa and ±10 Pa from 400-1200 Pa.

- Resolution: $\leq$ 0.5 Pa.
- Operational temperature range: -45°C to +55°C.
- Response time: $\leq$ 1 s.

3 MEDA HS

MEDA HS is a miniature relative humidity device based on polymeric capacitive Humicap® humidity sensors developed by Vaisala Inc. As in MEDA PS, the measurements are controlled by Vaisala proprietary ASIC. The same technology has previously been used in MSL (REMS-H).

The humidity device is mounted on the Remote Sensing Mast providing ventilation with the ambient atmosphere through a filter protecting the device from airborne dust. Humicap® sensors are located on the PCB inside a protecting cylindrical Faraday shield. Dimensions of the instrument are 55 mm x 25 mm x 95 mm and the total mass is approximately 45 g. Power consumption during nominal measurements is less than 20 mW.

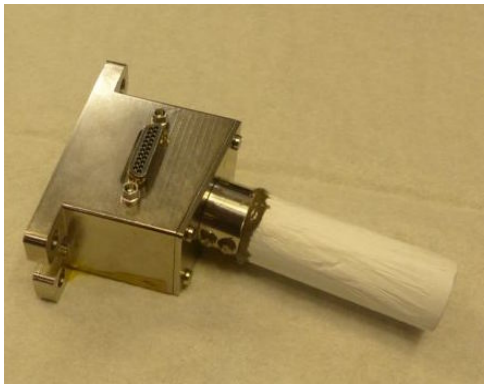

Figure 2: Engineering model of MEDA HS.

3.1 MEDA HS Performance

- Measurement range: 0-100% RH in -83°C to -3°C
- Accuracy: $\pm$10% RH in temperatures greater than -70°C, and $\pm$20% RH in -83°C to -70°C.
- Resolution: $\leq$1% in -83°C to -3°C.
- Operational temperature range: -128°C to +50°C (scientific measurements meaningful down to -83°C only).
- Response time: $\leq$30 min for temperatures above -70°C.

4. Measurements on Mars

MEDA HS enables investigations of atmospheric humidity variations of both diurnal and seasonal scale to better understand the Martian hydrological cycle. MEDA PS will measure the dynamics of the Martian pressure environment and is also able to detect pressure changes with a variation speed of at least 1 Pa/s.

MEDA is powered on and checked out already during the cruise towards Mars. The Flight System will calibrate MEDA HS and PS at zero pressure at least once during the cruise phase. Pressure and relative humidity measurements on Mars are recorded by ICU at least once per hour. MEDA PS and MEDA HS and the whole MEDA sensor package is expected to operate for at least 1 Martian year.

5. Summary and Conclusions

MEDA's goal is to help understand the Martian surface conditions by sampling the near surface environment. The MSL REMS heritage permits easier comparisons to measurements taken from the meteorological station on MSL in Gale Crater. After 2020 NASA's Mars rover landing and ExoMars 2020 landing it is possible to get pressure and relative humidity measurements from at least two locations on Mars simultaneously. Surface measurements from multiple locations will significantly help to validate global atmospheric models and understand the relations between the surface environment and large scale dynamics.

References

[1] J.A. Rodriguez-Manfredi et.al.: MEDA: an environmental and meteorological package for the Mars 2020 mission, 45th Lunar and Planetary Science Conference (2014)

[2] NASA website, "Mars 2020 Rover", https://mars.nasa.gov/mars2020/