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Status of METEO-P pressure and METEO-H humidity device development for the ExoMars 2020 mission

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Abstract

Finnish Meteorological Institute (FMI) has developed a compact instrument pair for the ExoMars 2020 mission, consisting of the METEO-P pressure and METEO-H humidity measurement devices. The instruments have novel features, but the core technologies have extensive heritage from FMI's previous Mars missions. The devices are part of the METEO meteorological instrument package on board the Russian led Surface Platform (SP) element of the mission. METEO package includes also a thermometer and an anemometer from IKI, Russia, as well as the RDM Radiation and dust sensors, and the AMR magnetic field sensors from INTA, Spain. The Surface Platform is a stationary lander hosting a set of science investigations and delivering the European Space Agency rover element to the surface of Mars.[1]

1. Introduction

The miniature low-power instrument pair operations are managed by the instrument controller integrated on the METEO-P board. Mass of the pressure device is ca. 75 g and mass of the humidity device is ca. 45 g. During a pressure or humidity measurement sequence the instrument pair uses ca. 100-120 mW of power.

METEO-P is located in the same internal warm compartment with the METEO Central Electronics Unit (CEU), and interfaces with the CEU using an RS-422 data interface. The instrument controller handles power distribution and measurement collection of the two pressure transducer on board METEO-P and the one humidity transducer on METEO-H located on top of the meteorological mast. An automotive microcontroller (MCU), the Freescale MC9S12XEP100 is used for the METEO-P/H instrument control. The MCU was custom qualified for Mars missions by FMI in frame of the DREAMS-P and DREAMS-H pressure and humidity instrument pair for the ExoMars 2016 Schiaparelli mission[2].

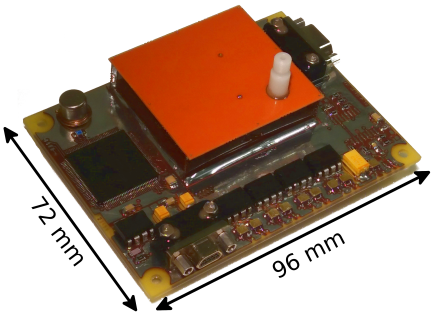

Figure 1: METEO-P pressure device STM

The measurement devices are based on capacitive Vaisala Barocap® pressure and Humicap® humidity sensors. Similar sensors have been flown on FMI's 6 previous Mars instrument projects and the Cassini-Huygens Titan lander. NASA's Curiosity rover is currently operating FMI's REMS-P and REMS-H devices in Mars.

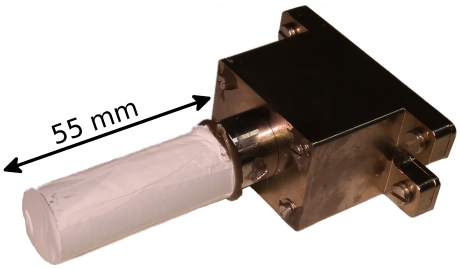

Figure 2: METEO-H humidity device STM

Compared to previous FMI designs, METEO-H uses a new type of Humicap® humidity sensors. The

new sensors offer a higher dynamic range and better knowledge of the sensor chip temperature through temperature sensors integrated on the chip. Measurement circuit for these PT1000 sensors has been implemented on the instrument controller on METEO-P board. Also, humidity sensor regeneration is now implemented through a PWM modulated voltage line and will heat up the humidity sensor heads to the required 160-165 °C regeneration temperature inside a wide range of environmental atmospheric temperatures.

2. Development status

Because of significant heritage of pressure and humidity devices developed by FMI, a lightweight model philosophy was selected for METEO-P and METEO-H development, including the following models:

- Structural and Thermal Model (STM)
- Electrical Interface Model (EIM)
- Protoflight Model (PFM)
- Flight Spare (FS)
- Humidity sensor Ground reference model

Both METEO-P and METEO-H STMs were manufactured in 2017 and delivered from FMI to IKI in Fall 2017.

The METEO-H Electrical Interface Model is fully representative and almost identical to the PFM. The METEO-P pressure device EIM is almost fully representative compared to PFM, but the type of the connectors was changed, the PCB corners rounded and few lay-out mistakes fixed to the PFM design. The EIMs have also been delivered from FMI to IKI.

PFM, FS and the ground reference model for METEO-H have been manufactured. As of May 2018, these models of the humidity device are now waiting for the beginning of humidity calibration process. The PFM and FS models of the METEO-P pressure device are under manufacturing and are expected to be completed in the beginning of June 2018. METEO-P PFM and FS will be then functionally tested and the pressure calibration process will be started.

3. Calibration

Both METEO-P and METEO-H are calibrated by FMI in FMI facilities.

For METEO-H the calibration of relative humidity requires in minimum two humidity points - dry (0%RH) and (near)saturation (95-100%RH) - over the expected operational temperature and pressure range of the device. We have developed a custom-made, small, relatively low-cost calibration chamber able to produce both dry points and saturation points in Martian range pressure CO_2 , in temperatures down to -70 °C. The system utilizes a commercially available temperature chamber for temperature control, vacuum vessels and pumps. In this system dry point, low-pressure CO_2 environment is achieved by filling the main pressure vessel with dry CO_2 gas until the desired pressure is achieved. The saturation point is then achieved by adding some water vapor from the saturation chamber to the main pressure vessel.[3]

METEO-P is calibrated in different constant temperature and pressure points in vacuum and in Martian pressure, in changing temperature and in rapidly changing pressure. Calibrations are performed inside a small vacuum chamber placed inside a temperature test station. Pressure is controlled with a commercial pressure controller and calibrations are calculated against Mars-range pressure references traceable to national standards.

References

[1] ESA website ExoMars mission (2020)

[2] T. Nikkanen (1,2), W. Schmidt (1), A.-M. Harri (1), M. Genzer (1), M. Hieta (1,2), H. Haukka (1) and O. Kemppinen: Space qualification of an automotive microcontroller for the DREAMS-P/H pressure and humidity instrument on board the ExoMars 2016 Schiaparelli lander. European Planetary Science Congress 2015. EPSC Abstracts, Vol. 10, EPSC2015-465.

[3] M. Genzer (1), J. Polkko (1), T. Nikkanen (1,2,3), M. Hieta (1,2) and A.-M. Harri (1): Calibration of Relative Humidity Devices in Low-pressure, Low-temperature CO 2 Environment. EGU General Assembly 2017. Geophysical Research Abstracts, Vol. 19, EGU2017-19164