MECA ELECTROMETER: INITIAL EXPERIMENTAL RESULTS.

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Introduction: The Mars '01 lander contains an electrometer designed to evaluate the electrostatic nature of the Martian regolith (soil) and atmosphere. The electrometer is part of MECA (Mars Environmental Compatibility Assessment) project. The objective is to gain a better understanding of the hazards related to the human exploration of Mars The sensor has an electric field sensitivity of 35 kV/cm·V and room temperature drift of ~3 μV/sec. The sensor has been operated as low as –60°C where the drift is undetected.

Electrometer: As seen in Fig. 1, the instrument has four sensor types: (a) triboelectric field, (b) electric-field, (c) ion current, (d) temperature. The triboelectric field sensor array contains five insulating materials to determine material charging effects as the scoop is dragged through the Martian regolith.

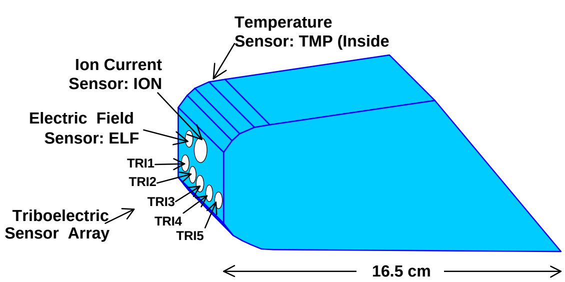

Figure 1. Electrometer sensor suite mounted in the heel of the Mars '01 scoop. The electrometer operates over an 8-wire serial interface, is housed in a volume of ~50 cm^3, consumes less than 250 mW, and weighs ~50 g.

In operation, the scoop will be rubbed against the Martian soil as depicted in Fig. 2. Then at the end of the rubbing period, the scoop will be raised and the response of the triboelectric sensors measured. Recommended operational parameters are: D1 = 10 cm is the traverse distance, D2 = 1 cm is the liftoff distance, D3 = 0.5 to 1 cm is the penetration depth, t1 = 10 s is the traverse time, t2 = 0.5 s is the liftoff time, t3 = 1 s is the switch close time, t4 = 19 s is the data acquisition time, and t5 = 0.1 s is the time between data points.

Of concern is dust cling to the sensors after lift off. The dust will reduce the triboelectric response. Various particle removal techniques will be explored.

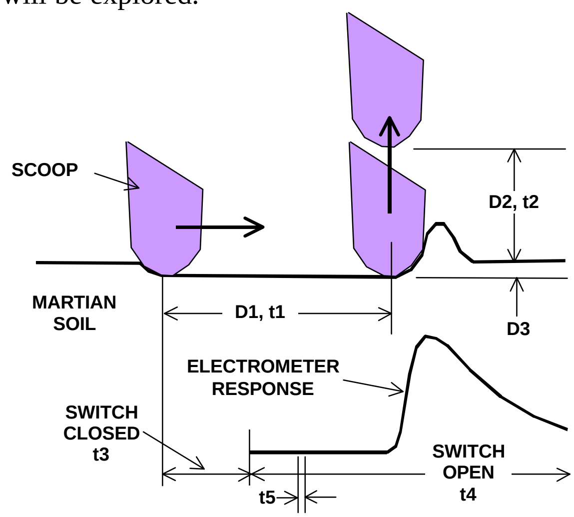

Figure 2. Operational scenario for the scoop

Experimental Results: In order to test out the viability of the apparatus, preliminary experiments involved the rubbing of sensors on wool. The results from prototype 7, ELE7, are shown in Fig. 2. The prototype was mounted on an automatic rubbing apparatus and the five triboelectric sensors were rubbed on wool. The results show that Teflon has the largest negative response which is expected from the Triboelectric series [1]. The response also shows the slow leak of the charge from the sensors.

Note that the sensor, TRI3, which was covered with a sheet of the antistatic material, Velostat, did not responsed. This is because the current data acquisition rate of one sample every 1.5 seconds is too slow to capture the fast transient from Velostat. The rate needs to be one sample every 0.1 second.

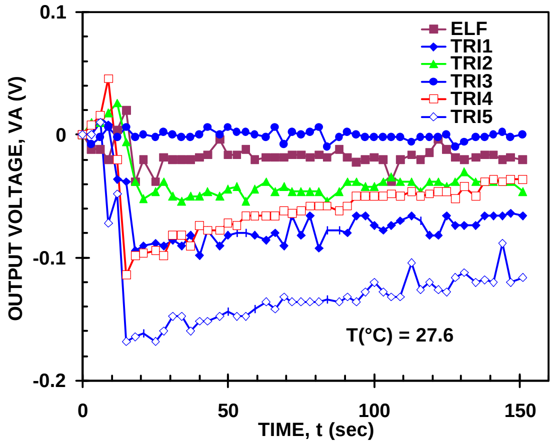

Figure 3. Rubbing experiment where triboelectric sensors were rubbed with wool felt. TRI1 is ABS, TRI2 is polycarbonate, TRI3 is Velostat, TRI4 is Rulon-J, and TRI5 is Teflon.

The results in Fig 4 show the response for two, millimeter-size basalt particles placed on TRI3. After a baseline period lasting 30 sec, the first particle was blown off the sensor using a nitrogen gas jet where upon the first downward response was measured. At the moment the particle was removed from TRI3 it landed on ELF which had a positive response. The second particle was removed after 50 sec and the second downward shift was measured.

Discussion: Further experimentation is planned in Mars simulators where the atmosphere will be CO_2 at 5 mb and the temperature will be controlled to between –60 and 20°C. The soils planned are hematite, basalt, and quartz.

Conclusions: Preliminary results from the electrometer are encouraging. They show that rubbing with wool produces a strong (in the 0.1 V range) response using an automated rubbing apparatus. In addition, the charge on a single basalt particle was easily detected. This suggests that this apparatus can be used in particle cleaning experiments where the removal of charged particles is detected by an abrupt change in the electrometer response.

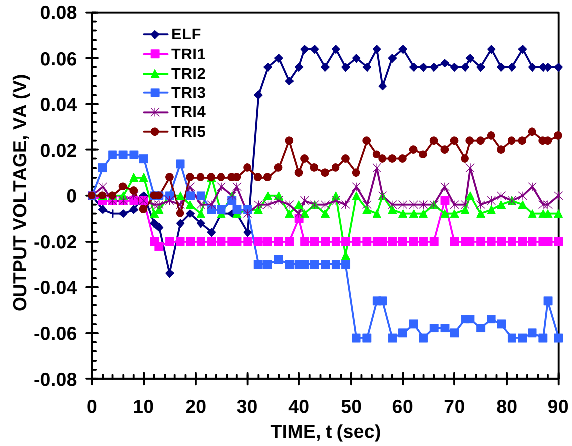

Figure 4. Room ambient particle removal experiment using TRI3. TRI1 is ABS, TRI2 is polycarbonate, TRI3 is Teflon, TRI4 is Rulon-J, and TRI5 is Teflon.

References:

1. J. A. Cross, "Electrostatics: Principles, Problems and Applications", Adam Hilger (Bristol, UK)

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