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Magnetic perturbations from thermoelectric currents in Swarm thermal blankets

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The Swarm mission is delivering high quality scientific measurements of the Earth's magnetic field. The measurements are provided by the dual magnetometer instrumentation package, on each of the three Swarm satellites, consisting of an absolute scalar magnetometer (ASM) and a vector field magnetometer (VFM). During commissioning of the three satellites it was realized that a discrepancy of up to 5nT existed between the scalar field measurement of the ASM and the scalar field from the VFM, computed as the root sum square of the three components. An analysis of the scalar residual demonstrated a strong correlation to the sun impingement on the satellite and indicated that the discrepancy was related to the VFM measurements. On this basis an empirical model of the magnetic disturbance vector based on spherical harmonics expansion of the sun impingement angles was proposed. This model is currently used to compensate the VFM measurements.

In connection with the root-cause-analysis of the scalar residual a thorough on-ground magnetic survey of the materials around the VFM sensor has been performed. Focus was on thermoelectric currents as the perturbation seemed to be induced by solar heat flux. The thermal blanket that covers the VFM sensor is grounded to the electrical network of the satellite to prevent built up of static electricity. For redundancy reason this grounding is done at two rivets on the blanket connecting the aluminized MLI blanket and an outer titanium wire with copper wires to the grounding network. This setup forms a thermoelectric circuit between the two rivets of the blanket. Measurements during the magnetic survey confirmed the thermoelectric circuit and demonstrated a current of 35μA for a temperature difference of 1^{0}C between the two rivets. The theoretical value taking the Seebeck coefficients and the electrical resistances of the blanket materials into account is 26μA/^{0}C.

The two rivets are placed at different locations of the blanket resulting in different view factors to the sun when mounted on the satellite. A temperature difference between the rivets will therefore arise as the satellite scan different sun impingements during flight. On the basis of energy conservation, the temperature difference of the two rivets can be modelled for any set of the sun impingement angles. From this a thermoelectric current can be calculated and the corresponding perturbation on the VFM sensor can be estimated. The modelled perturbation from the blanket is almost identical to the empirical disturbance vector (in x- and z-axis) and show features like sun shading by structural elements near the rivets.

The thermoelectric circuit of the VFM thermal blanket does not support a y-axis perturbation on the VFM sensor. However a similar blanket near the ASM sensor has a geometry that would generate such a perturbation from thermoelectric currents between the two rivets of this blanket. An analysis of this blanket verify that the empirical disturbance vector in y-axis originate from this blanket and perturbs the ASM. This has also been verified in-flight during maneuvers by inter-satellite comparisons of ASM readings.