Lightweight RF Power Cables with High Phase Stability

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5) Organizational unit: Departement Maschinenbau und Verfahrenstechnik, Institut für Mechanische Systeme (IMES), Ermanni, Paolo, permanni@ethz.ch, LZ=03507

6) Project leader(s):  
   - Kress, Gerald, gkress@ethz.ch, Dep. Maschinenbau und Verfahrenstechnik, Inst. f. Design, Mat. und Fabrikation

7) ETH researcher(s):  
   - Kress, Gerald, gkress@ethz.ch, Dep. Maschinenbau und Verfahrenstechnik, Inst. f. Design, Mat. und Fabrikation  
   - Ponurovska, Tetiana,

8) External researcher(s):  
   - Mattes, Michael, michael.mattes@epfl.ch

9) Funding source(s):  
   - Others

10) Partner organizations:  
   Ecole Polytechnique Federale Lausanne - EPFL, 1015, Lausanne, Switzerland,  
   http://www.epfl.ch/
11) **Short Summary:** The objective of this activity is to design, manufacture and test radio-frequency (RF) cables for space applications with excellent phase stability and with a significant reduction in the overall weight compared to current cables. This will become critical in the new generation of telecom cables.

12) **Keywords:** Aerospace Engineering

13) **Project description:**
So far reducing weight by e.g. reducing the mass of the dielectric (foamed or sintered material with large amount of air in the volume) led to lower mechanical stability and phase linearity. Additionally, the commonly used PTFE (Teflon) undergoes a structural phase change at 20°C that causes a nonlinear phase change with temperature due to the changing dielectric constant. Moreover, when operating cables at high power levels the temperature inside the cable becomes high. This high temperature is responsible for significant thermal expansion mismatch between the dielectric and the conductors which result in important phase shifts of the electrical signal and in a significant distortion of the signal quality in the end. So, phase changes in the RF signal due to poor mechanical stability and heat dissipation from the inner conductor therefore pose new technological and design challenges that have to be carefully studied and modeled. The heat evacuation from the cable and the choice of materials that reduce to a minimum the cable’s thermal expansion will be an important issue in this planned project.

Traditional ways of modeling cables will not be sufficient to describe the mechanical changes of a cable with changing temperature, air pressure and mechanical stresses. In this activity we will follow a complete numerical way of the mechanical design of the cable.

Therefore the Centre of Structure Technologies of the ETHZ is part of the consortium.

To solve these issues the necessary theory and modeling will be developed to predict thermal characteristics, loss, phase stability and RF breakdown in coaxial lines. As cable assemblies are the final products both the cables and the connectors will be included in the theory.

In conclusion the task is the

- Design, manufacture and test of ultra-light RF cables with
  - excellent phase stability,
  - significant reduction in the overall weight by 30 to 40%,
  - capability for power levels up to 50 W cw and
  - low passive intermodulation.

To achieve this goal an

- intensive modelling and simulation work has to be carried out to predict
  - mechanical stability,
  - influence of mechanical stress by e.g. bending,
  - loss,
  - phase stability,
  - RF breakdown (corona, multipactor),
  - passive intermodulation, and
  - thermal characteristics, maximum temperature.
HUBER+SUHNER will be responsible for the project management and the consolidation of all the inputs provided by the subcontractors EPFL and ETHZ. The project is divided in two phases: phase 1 is dedicated to a review of the current state of the art and a review of the specifications, and the complete design of the new lightweight cable including all studies, mechanical analysis and optimizations and electromagnetic simulations regarding corona discharge and multipactor as well as power handling capabilities, and nonlinearities leading to phase instability. EPFL will be responsible for the electromagnetic modeling of the cables and cable assemblies and the work on multipactor, corona discharge and thermal analysis, ETHZ for the phase stability and part of the mechanical analysis. HUBER+SUHNER will concentrate on the mechanical analysis, the prototypes and acceptance criteria. In phase 2 the cable assembly kits will be manufactured according to the design gained in phase 1, tested, characterized and analyzed. Especially the high power measurements regarding multipactor and corona discharge threshold, mechanical performance (phase stability) and S-parameters under thermal vacuum will be an essential part of this phase and the whole project. The measurements will be done in the L-band, the C-band and the Ku-band. A minimum of 3 cable assembly sets will be manufactured and tested. Design limitations and possible improvements will be identified.

14) Popular description:
Radio frequency co-axial cables on telecommunication satellites must be extremely light and their electric properties must remain the same over a very large temperature range. Current cable designs use as a dielectric, for separating the inner from the outer conductor, Teflon, which changes its electric properties around 20o Celsius. The heat produced by the electric current causes temperature increases which cause free strains in the cable materials. The research includes simulations of the mechanical interactions between all cable components to find best design solutions for all temperature or mechanical loads. Also, the dependency of the electrical performance on changes of geometry due to deformations must be described with models. These will be quite challenging as they must include mapping of the contact problem and strength assessments.

15) Graphics:

SucoPearl (cable component serving as dielectric) geometry parameters

G. Kress, Laboratory of Composite Materials and Adaptive Structures (CMAS)
Schematic for bending induced eccentricity kinematics of SucoPearl chain

G. Kress, Laboratory of Composite Materials and Adaptive Structures (CMAS)

16) Publications:  no entry

17) Links to important web pages: