All-metal 3D Printing of Microwave Components for Space-borne Applications

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Abstract

Antennas systems generating hundreds of beams are envisaged to be embarked on next-generation satellites for different Space application domains [1], among which are

- Satellite telecommunication, in the context of very-high throughput satellite (VHTS) networks providing Terabit/s aggregate capacity.
- Earth Observation, where multi-frequency multi-beam radiometers will provide high space-resolution and complete on-ground coverage for climate-change monitoring.
- Cosmology, where receivers arrays for CMB polarization detection demand very high sensitivity that translates in a very high number of beams.

The baseline antenna-system configuration for these applications consists of a compact high-dense focal-plane with hundreds of multi-band dual-polarization antenna-feed systems illuminating a single reflector. The block diagram of a common antenna-feed chain architecture used in Space-born applications is shown in Fig.1. Because of the high number of components, the implementation of hundreds of antenna-feed systems implies severe constraints in terms of mass, envelope, cost and lead time, and very complex assembling/integration/testing activities. In this view, Additive Manufacturing (AM) is regarded as an enabling technology due to several characteristics, among which is the possibility of building monolithic assemblies with near-net shapes integrating several RF functionalities. Among the several AM technologies available, the ones most studied for microwave waveguide and antenna applications are Fused Deposition Modelling (FDM) [2], Stereo-lithography (SLA) [3], binder-jetting [4], and Selective Laser Melting [5], [6]. Compared to other AM technologies, the SLM process offers the advantage of building aluminium parts with good mechanical/thermal properties and a surface electrical conductivity in the order of 16 $\mu\Omega$cm, thus not requiring any additional metal coating. The accuracy is in the order of 30-50 μm depending on the component shape and orientation in the building chamber, whereas the surface roughness is moderately high (Ra < 10 μm). The authors will present the on-going research activity on this technology, covering all the aspects of the supply chain (i.e., design, material, processing, post-processing and testing) aimed at the development of high-performance SLM components operating in the frequency range 15-50 GHz. Figures 2 and 3 reports two prototypes built through SLM along with the comparison between the measured and predicted performance.

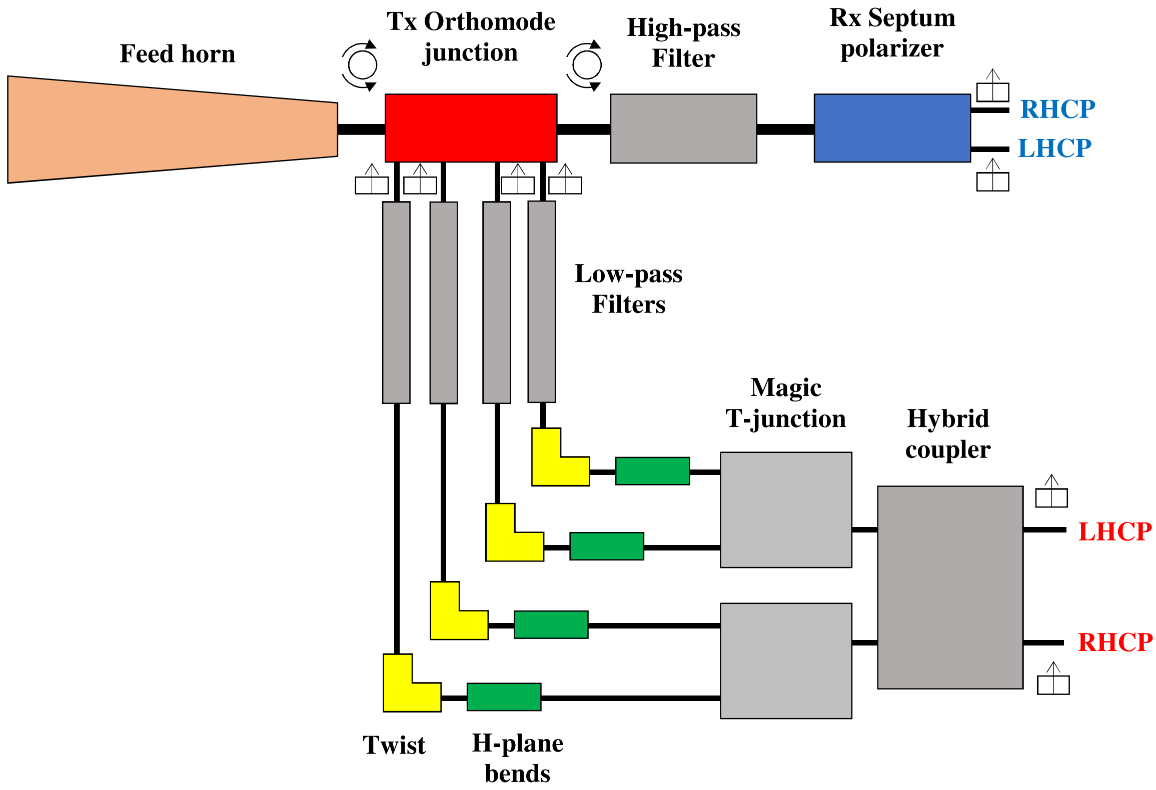

Fig. 1. Block diagram of a dual-band dual-polarization antenna-feed chain for multi-beam Space applications.

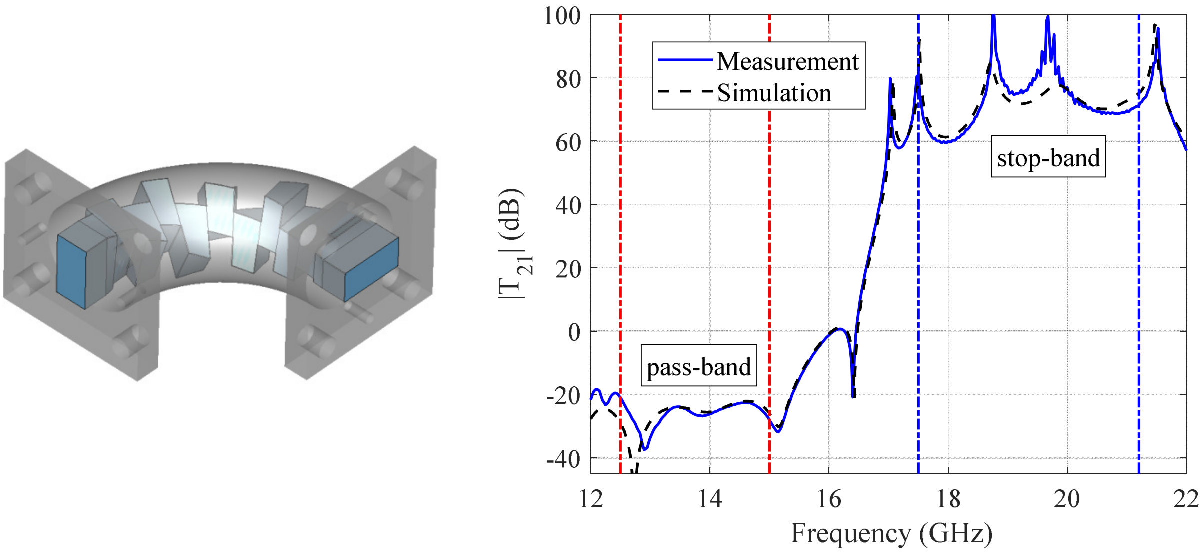

Fig. 2. Ka-band orthomode transducer integrated with a 90-deg twist. Left: 3D CAD of the component optimized for selective laser melting manufacturing. Right: comparison between measured and predicted performance of the prototype.

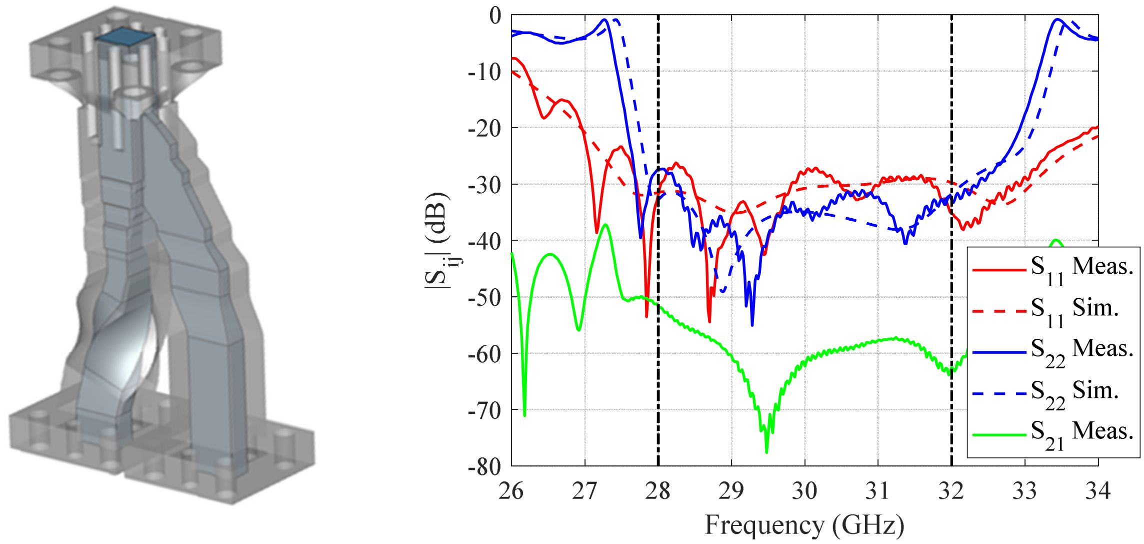

Fig. 3. Ka-band orthomode transducer integrated with a 90-deg twist. Left: 3D CAD of the component optimized for selective laser melting manufacturing. Right: comparison between measured and predicted performance of the prototype.

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