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Development of a broadband waveguide Dual-Polarization Sixteen-Way Power Divider for Small Passive Arrays in a single block optimized for additive manufacturing.

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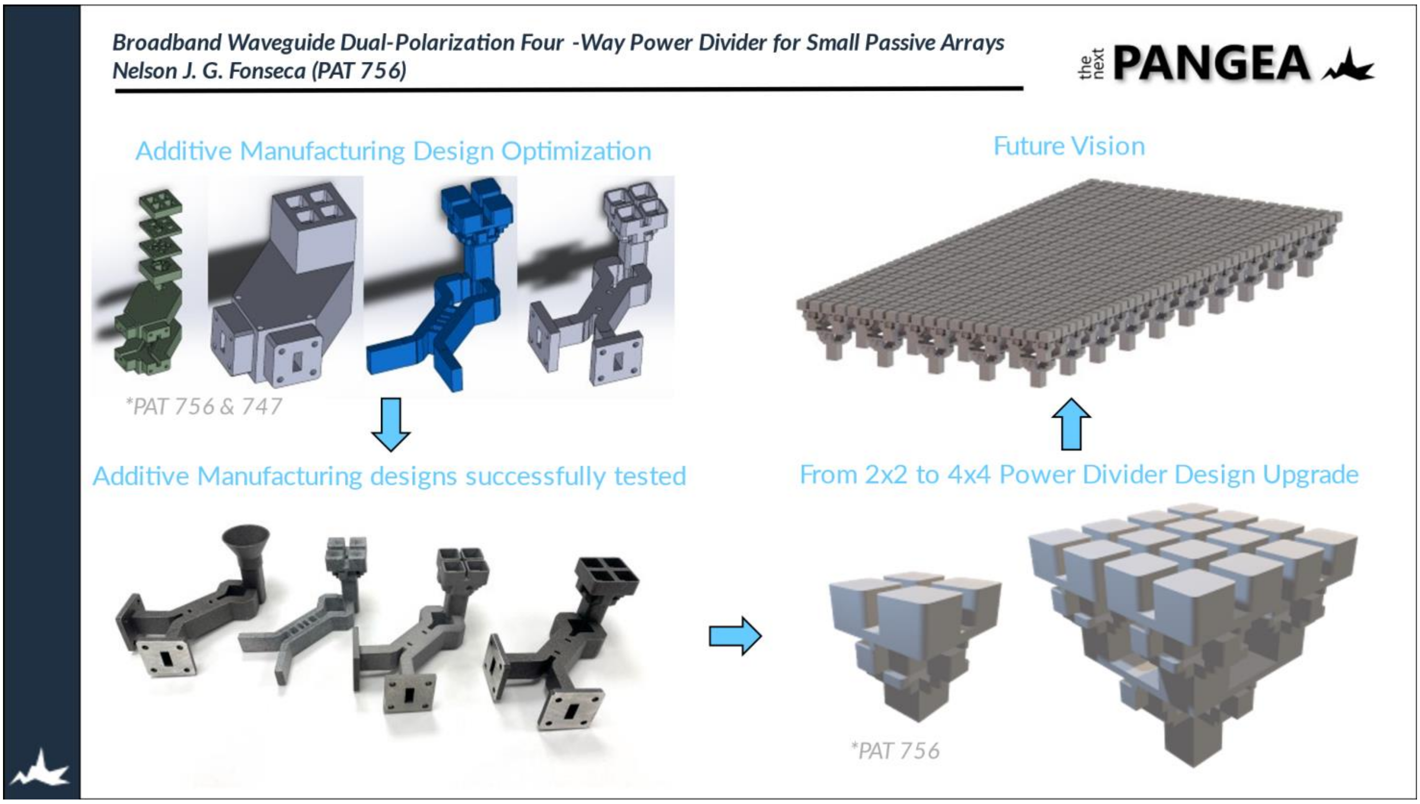


Objective

The main objective of the proposed activity is to successfully manufacture and test a 4x4 array fed with a 16-way power divider, that will be purposedly designed to be manufactured in one single block structure using additive manufacturing techniques.

ESA Patent 756 presents a compact dual-polarization four-way power divider, enabling the design of passive waveguide arrays with small element spacing (below one wavelength). That invention was originated as a mean to reduce the length of radiating elements in space-segment feed systems for GEO satellite communication applications, including passive multiple beam reflector antennas and active arrays. This requires compact power dividers, preferably operating in dual-polarization. The next step for extending the already proven four-way power divider, is to scale it up to a sixteen-way power divider by combining four four-way power dividers on the top layer and addressing a fifth power divider, as a waveguide component, to feed the four top power dividers. As a result, the design will have a single port as a feed and four by four radiating elements. This structure could be joined to an additional component that allows the whole structure to work in dual-polarization. However, there are no compact solutions for waveguide feed chains that do not compromise RF performance. For that reason, there is also a connection with another ESA patent that could fit in this presented idea. ESA Patent 747 presents a two-probe Orthomode Transducer (OMT) or junction (OMJ) which provides high cross-polarization discrimination (XPD) thanks to an asymmetric common waveguide cross-section. The presented idea aims to demonstrate the potential that additive manufacturing has for RF components and space application, as well as the potential for the presented power divider as a key component for the ground segment in the satellite communications sector. So, for that reason a single block structure is proposed to be manufactured with advanced manufacturing technologies, such as Laser Powder Bed Fusion or Binder-jetting, to show the capabilities of alternative manufacturing methods in this field.

Development

The project involves the development of a 16-way power divider customized for a 4x4 array configuration. By leveraging the potential of broadband waveguide technology and dual-polarization features, this innovation aims to significantly improve the functionality and efficiency of small passive arrays. The distinctive design approach involves consolidating the entire structure into a single block, changing the manufacturing process from machining to additive manufacturing techniques. This strategy aims to improve manufacturability and also optimize performance and reliability.

- Innovative Design: The project focuses on the design of a 16-way power divider customized for a 4x4 array, leveraging the advantages of broadband waveguide and dual-polarization characteristics.
- Advanced Manufacturing Techniques: Utilizing additive manufacturing methods, the objective is to create a single block structure, boosting reliability and performance while reducing production complexities.
- Performance Enhancement: The proposed solution aims to improve the functionality and performance of small passive arrays, ensuring broader bandwidth and virtually eliminating noise derived from alignment problems during assembly.

- Technological Significance: By combining RF design principles with additive manufacturing, the project targets a breakthrough in the realm of power divider construction, paving the way for future advancements in array systems.

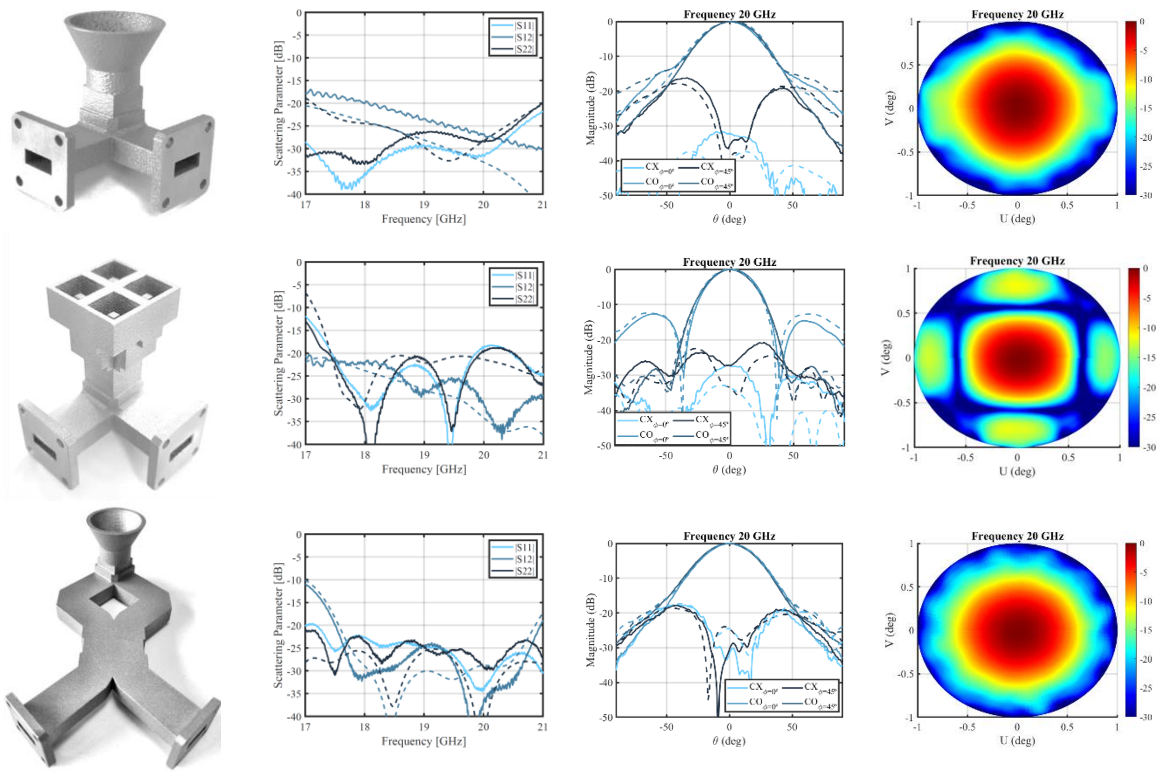
This project started with the creation of a linear Orthomode Transducer (OMT). Progressing from this initial phase, the focus shifted towards the design and manufacturing of a four-way power divider, which would later be combined with the OMT.

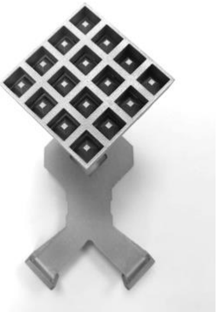
After this milestone, the project continued with the development of a riblet-coupler based circular OMT. This development expanded the design spectrum and allowed for enhanced functionalities and capabilities within the structure.

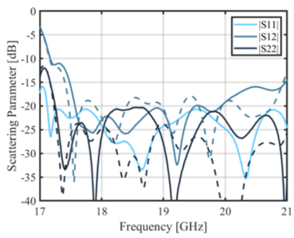
During the final phase, the project reached its final stage with the development of the sixteen-way power divider customized for a 4x4 array configuration. The assembly of the riblet-coupler based circular OMT with the sixteen-way power divider marked the end of the project.

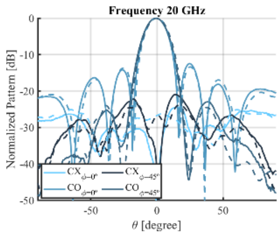
The step-by-step progression from the linear OMT to the sixteen-way power divider underscores the systematic approach adopted throughout the project. Each phase contributed significantly, building upon the preceding advancements, ultimately leading to the successful realization of the project's primary objective.

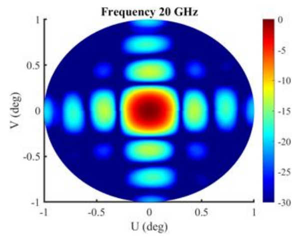
Results











Conclusion

The successful completion of this project represents a significant milestone in the field of array system technology. Through the development and testing of four prototypes, calibrated to align with simulations, the primary objective has been successfully achieved. The prototypes, manufactured through additive manufacturing technology and tested against simulation-based parameters, show the feasibility and effectiveness of the designed 4x4 array integrated with the innovative sixteen-way power divider.

By validating the prototypes against simulations, this project reaches its goal, demonstrating the capacity to manufacture and validate a high-performance array system. This successful outcome proofs the feasibility of the single-block, additive manufacturing-optimized structure and underscores its potential to significantly improve the functionality, efficiency, and reliability of small passive arrays.

The completion of this project marks a milestone in technological innovation and marks a promising trajectory for the future of array systems, where pioneering design principles and advanced manufacturing techniques aim to redefine industry standards.