IAF SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Advances in Space-based Communication Technologies (7)

Author: Mr. Navdeep Singh
India

Mr. Aniket Bire
Texas A&M University, United States
Ms. Jasleen Kaur
Texas A&M University, United States

DESIGN AND OPTIMIZATION OF MIMO ANTENNAS WITH DEFECTED GROUND STRUCTURES FOR HIGH-PERFORMANCE C AND X-BAND SATELLITE COMMUNICATION

Abstract

This research presents the design and performance enhancement of a 4-port Multiple-Input Multiple-Output (MIMO) antenna operating at 7.25GHz - 7.75GHz (Uplink) and 7.75GHz - 8.30GHz (Downlink), tailored for Satellite particularly in the communication applications. The antenna design is based on a really thin substrate with a height of 0.8 mm, which is a critical feature for achieving a compact and lightweight structure, essential for space-constrained applications such as satellite communications. When you're sending stuff into space, every little bit of weight matters. The antenna incorporates circular radiating patch with a tapered microstrip feed line printed on the top plane and a Defected Ground Structure (DGS) on the opposite plane. The inclusion of the DGS is instrumental in enhancing electromagnetic wave propagation by controlling the surface currents and improving antenna performance metrics such as bandwidth, isolation, and gain. Even though this 4-port MIMO setup is pretty small (4242 mm), it seriously boosts the bandwidth, reaching from 5.50 GHz to 11.61 GHz. High isolation in a 4-port MIMO system prevents signal interference between ports, ensuring better performance.The proposed design maintains an isolation level greater than 20.0 dB, which is more than sufficient for MIMO antenna systems operating in demanding environments. In terms of gain, the 4-port MIMO setup further improves the gain to 5.41 dBi, ensuring better signal strength and range, particularly in satellite communication, where signal loss can be significant. The Envelope Correlation Coefficient (ECC), which measures the correlation between signals from different antenna elements, is less than 0.0000125 at 7.25 to 8.30GHz, indicating excellent diversity performance and minimal correlation between signals. The Diversity Gain (DG) exceeds 10.0 dB, which ensures improved communication reliability in multipath environments. The Total Active Reflection Coefficient (TARC) is maintained below - 20 dB, which indicates minimal signal reflection and efficient signal transmission.

The incorporation of a Defected Ground Structure (DGS) in the design is a key innovation, as it allows for enhanced control over the antenna's electromagnetic characteristics. The DGS technology, combined with the thin substrate, results in a compact and lightweight antenna solution ideal for satellite applications, where space, weight, and power consumption are critical considerations. The proposed antenna design employs circular-patch radiators due to their favourable characteristics, including circular polarization and symmetrical radiation patterns, which are ideal for satellite communication. A thin substrate is utilized to ensure a lightweight and compact design, crucial for space applications where size and weight are critical constraints.